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

Proceedings of the International Conference

Date: September 16

Beijing, China 2020

上合组织国家的科学研究：协同和一体化
国际会议

参与者的英文报告

International Conference
"Scientific research of the SCO countries: synergy and integration"

Part 1: Participants' reports in English

2020年9月16日。中国北京
September 16, 2020. Beijing, PRC

Proceedings of the International Conference
"Scientific research of the SCO countries: synergy and integration". Part 1 - Reports in English

(September 16, 2020. Beijing, PRC)

这些会议文集结合了会议的材料 – 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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These Conference Proceedings combine materials of the conference – research papers and thesis reports of scientific workers. They examines tecnical and sociological issues of research issues. Some articles deal with theoretical and methodological approaches and principles of research questions of personality professionalization.

Authors are responsible for the accuracy of cited publications, facts, figures, quotations, statistics, proper names and other information.

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Foreword

We thank all participants of our conference "Scientific research of the SCO countries: synergy and integration" for the interest shown, for your speeches and reports. Such a wide range of participants, representing all the countries that are members of the Shanghai Cooperation Organization, speaks about the necessity and importance of this event. The reports of the participants cover a wide range of topical scientific problems and our joint interaction will contribute to the further development of both theoretical and applied modern scientific research by scientists from different countries. The result of the conference was the participation of 83 authors from 7 countries (China, Russia, Uzbekistan, Belarus, Kazakhstan, Azerbaijan, Kyrgyzstan).

This conference was a result of the serious interest of the world academic community, the state authorities of China and the Chinese Communist Party to preserve and strengthen international cooperation in the field of science. We also thank our Russian partner Infinity Publishing House for assistance in organizing the conference, preparing and publishing the conference proceedings in Chinese Part and English Part.

I hope that the collection of this conference will be useful to a wide range of readers. It will help to consider issues, that would interest the public, under a new point of view. It will also allow to find contacts among scientists of common interests.

Fan Fukuan,
Chairman of the organizing committee of the conference
"Scientific research of the SCO countries: synergy and integration"
Full Professor, Doctor of Economic Sciences

前言

我们感谢所有参加本次会议的"上海合作组织国家的科学研究：协同作用和整合"，感谢您的演讲和报告。代表所有上海合作组织成员国的广泛参与者都谈到此次活动的必要性和重要性。参与者的报告涵盖了广泛的主题性科学问题，我们的联合互动将有助于不同国家的科学家进一步发展理论和应用的现代科学研究。会议结果是来自7个国家（中国，俄罗斯，乌兹别克斯坦，哈萨克斯坦，阿塞拜疆，塔吉克斯坦，吉尔吉斯斯坦）的83位作者的参与。

这次会议的召开，是学术界，中国国家权力机关和中国共产党对维护和加强科学领域国际合作的高度重视的结果。我们还要感谢我们的俄罗斯合作伙伴无限出版社协助组织会议，准备和发布中英文会议文集。

我希望会议的收集对广大读者有用，将有助于在新的观点下为读者提供有趣的问题，并且还将允许在共同利益的科学家中寻找联系。

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香港的经济和政治前途
HONG KONG'S ECONOMIC AND POLITICAL FUTURE

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抽象。这篇文章的相关性是由于与香港的特殊地位有关的世界最大经济体的严重变化，香港正迅速丧失其自主权和与之相关的特权。本文的目的是证实这一问题对整个世界经济的重要性，以证实香港经济和政治未来的可能前景和局限性。研究的主题是在与中国内地经济融合的背景下，香港在经济和政治领域的特征，趋势和发展模式。

结论。可以确定有多种情况：虽然完全废除香港的特殊地位似乎不太现实，因为它消除了可能按照"一国两制"的原则建立关系的尝试。

关键词：中国香港，地位，世界金融体系中心，自治，危机，抗议，大流行，冠状病毒，美国

Abstract. *The relevance of the article is due to serious changes in the world's largest economy related to the special status of Hong Kong, which is rapidly losing its autonomy and privileges associated with it. The purpose of the article is to substantiate the possible prospects and limitations of the economic and political future of Hong Kong, taking into account the significance of this problem for the entire world economy. The subject of the research is the features, trends and patterns of development of Hong Kong in the economic and political spheres in the context of economic integration with mainland China.*

Conclusions. *It is established that there can be multiple scenarios: while a full abolition of the special status of Hong Kong seems less realistic because it eliminates possible attempts to build relations on the principle of "one country, two systems".*

Keywords: *Hong Kong, China, status, center of the world financial system, autonomy, crisis, protests, pandemic, coronavirus, USA*

Introduction

The territorial and administrative division of China is a rather complex structure, especially for special and Autonomous regions. Together with 22 provinces

(except Taiwan, which the Chinese authorities consider their 23 province), there are 5 Autonomous regions and 2 special administrative regions: Hong Kong, which includes Hong Kong, and Macao, which is the center of Macao. Both are powerful economic centers with a large number of billionaires among the population (about 7 million residents of Hong Kong 500,000-millionaires). After 150 years of being under the protectorate of the British monarchy, China returned Hong Kong only at the end of the last century. The success of Hong Kong in recent years is based on the concept of "one country, two systems", which is the core of the Constitution introduced in 1997, which guarantees Hong Kong autonomy [9].

There are not many such examples in history, but despite the transition to Chinese sovereignty, Hong Kong remained de facto under its own jurisdiction [2]. This is clearly reflected in the existing border and visa restrictions between the mainland and the special Autonomous province (SAR), as well as in the fact that citizens of Hong Kong have their own passports. The terms of the special status provide for a transition period of 50 years, if there is no agreement on the status of this region after 2047. Since this trend continues today, Hong Kong has the opportunity to become a normal province of China in 28 years without any preferences.

Today, it is the "one country, two systems" model that makes Hong Kong unique and attractive for both international investors and residents of mainland China, who value the location of this territory as favorable for doing business [10]. For example, the international business community focused on the Chinese market after its accession to the WTO does not directly address the Chinese market, but rather Hong Kong entrepreneurs who know international business, as well as Chinese culture, rules and customs of doing business in China [12].

However, in 2019, this course of events is complicated by the current wave of anti-government protests, the international trade war between China and the United States, as well as the crisis in the economy associated with coronavirus infection and its consequences. In this regard, the problem of studying the economic and political directions of the future development of Hong Kong, taking into account the successful international experience, is urgent.

Main part

As the tenth largest trading economy and the third largest financial center in the world, Hong Kong is often referred to as a model of a liberal economy. However, the economy is currently slowing, and GDP grew by -1.2% in 2019, compared to 2.9% in 2018. This slowdown is due to China's cooling economy, trade tensions with the US, lower foreign direct investment and tighter credit conditions. According to the Financial Times, Hong Kong's economy has been affected by the protests. According to the IMF's updated forecasts of April 14, 2020, due to the COVID-19 outbreak, GDP growth is expected to decrease to -4.8% in 2020 and increase to 3.9% in 2021, depending on the post-pandemic global economic situ-

ation [11]. Retail trade and tourism are among the sectors bearing the brunt of the economic downturn.

The tertiary sector is the backbone of the Hong Kong economy. Financial services, trade and logistics, tourism, import / export, air transport, professional services are traditional key industries in Hong Kong. The service sector provides about 92.2% of GDP and accounts for almost 88.1% of the labor force (figure 1). Hong Kong acts as a service center for Asian companies, especially those who trade with China. According to the data published by the Commercial register, more than 900 thousand companies are registered in Hong Kong [11, 14].

In the midst of the coronavirus crisis, China is taking actions that could lead to potential sanctions from the West. Due to US concerns about China's competition for global leadership, a report has been developed, authorized by the US Congress, which assesses whether Hong Kong has sufficient autonomy to justify the special economic status it has with the US. In fact, under US law, which preceded the transfer of Hong Kong by the UK to China in 1997, Hong Kong is still considered a territory controlled by the UK. Recently, for example, this meant that Hong Kong was not subject to the tariffs that the US imposed on goods exported from the Chinese mainland. If the United States cancels the special status of Hong Kong, the status of Hong Kong as a world - important financial center and trading hub is under threat.

All U.S. trade with mainland China transits through Hong Kong to avoid U.S. tariffs. Changing the status of Hong Kong and imposing sanctions / tariffs on trade and financial flows in Hong Kong is used as a weapon in the US attempts to contain the growth of China's economic and geopolitical influence [13]. The revocation of the special status would have a special significance not only for Hong Kong, but also for Western capital and companies operating in this territory. This would also be very unprofitable for China itself [5].

In the US alone, there are about us $ 82 billion (us $ 123 billion) of direct investment and more than 1,300 companies operating in Hong Kong. Economic cooperation with Hong Kong is also developing in the countries of the European Union. Australian companies have invested more than us $ 50 billion in Hong Kong, and the volume of bilateral trade is approaching US $ 20 billion a year. Hong Kong is China's gateway to the global financial system; its key channel to the West for foreign capital and trade. About 1 trillion us dollars of trade flows pass through Hong Kong every year [11]. As a small open economy, Hong Kong is developing as an "independent" entity. But its growth mainly depends on imported resources and foreign markets. As its traditional manufacturing firms moved North to Canton to reduce costs, the share of Hong Kong's industry in its economy declined; this type of economy is subject to speculative bubbles or external fluctuations [15].

Since 1997, Hong Kong has become more closely connected to the mainland economy due to the city's ability to develop a developed service economy. This made Hong Kong an ideal place to benefit from structural shifts occurring on the neighboring mainland. Given the high factor costs in Hong Kong, it may lose its competitiveness if it does not accelerate integration with mainland China [8]. This is necessary not only because China provides Hong Kong with an internal territory with cheaper / skilled labor and less expensive land, but also because the advantages of primary and secondary industry can complement the advantages of Hong Kong in terms of capital and services and low transaction costs. Further economic mergers can make Hong Kong's economic structure more balanced and provide strong synergies for its long-term growth.

It is not clear why, in the midst of the economic problems that China is facing as a result of the coronavirus pandemic [1], its leadership chose this moment to take actions that could potentially trigger mass protests in Hong Kong and condemnation and possible sanctions from the West, not just the United States. The protests in the city were initially triggered by a bill allowing extradition to China. They later evolved into broader anti-government demonstrations that include demands such as greater democracy and universal suffrage.

In this regard, these protests can be considered as a tool in the us fight against the growing influence of China. [3] because if Beijing takes steps to establish Hong Kong as an offshore trading center for the yuan, London's current financial status may reflect Hong Kong's position in the world of Finance of tomorrow. In addition, London, like Hong Kong, has a developed service sector that accounts for 84% of its economy. In the early 1960s, American banks created the Eurodollar market in London to avoid internal banking regulation, and by the mid-1990s, London had become the largest financial center in the world. Hong Kong is able to follow a similar path, as the yuan is expected to grow in its use and influence in Asia and beyond, and China's economy will approach that of America in the future.

Another of the most unreported issues of the protests is the approval of the so-called " Hong Kong human rights and democracy act "to legislate the basic values and rights that should be provided by the local authorities in Hong Kong. This is a unilateral document of the United States, which was registered in Congress in 2017, but has not yet been implemented. The problem is that in 2017, for the first time in 20 years since Hong Kong became Chinese, the election of the head of the Hong Kong administration was held, but these elections, which are prescribed in the Basic law, are not direct. Some of them are chosen according to their area of residence, the other 1,200 people are chosen by the electoral College, and only a third are determined by direct voting.

As for the document "Hong Kong law on human rights and democracy", if approved, the initiator, the United States will be responsible for guaranteeing the

security rights of Hong Kong residents. The current "one country, two systems" approach is already too radically different from the priority version in 1997. The United States has already APPROVED A similar DECLARATION ," the United States-Hong Kong Policy ACT". in 1992, IT WAS EXCLUSIVELY UNILAT-ERAL AND FOCUSED the VECTOR of RELATIONS between the United States and Hong KONG, PRIMARILY on TRADE ISSUES. Subsequently, this led to the fact that the special Autonomous region does not have a de facto independent monetary policy, since the dollar exchange rate in Hong Kong is closely linked to the US dollar. In turn, the stability of the monetary unit attracts international companies and investors [6].

The economic situation in Hong Kong is very difficult. There is no doubt that there has been an outflow of capital in Hong Kong, although these trends are easing as the intensity of the protests has decreased in recent months. We should not forget that the US and China are in an active phase of a trade war, so Hong Kong risks becoming a kind of periphery for the first and second economies of the world. If these demands of the protesters were legally fixed, then the basic "basic law of the Hong Kong special administrative region of the people's Republic of China".

In addition, a measure was recently introduced in the US Senate to punish individuals and institutions in China associated with security laws and any banks that conduct commercial transactions with them. The US has very effectively used its dominance in the global financial system and the threat of sanctions against banks to block the flow of Finance and capital to countries such as Iran and Russia, as well as the rich and powerful people in them. There are a number of other possible sanctions, including visa restrictions for Chinese officials and ordinary citizens. America is also steadily adding to the list of Chinese technology companies whose activities it considers contrary to national interests; they currently insist that Chinese companies registered in the United States should be audited by American auditors. The tariffs that have been imposed on Chinese exports worth more than 360 billion US dollars also significantly limit the capabilities of the Chinese economy [7].

China believes that the strength of its own economy confirms the status of Hong Kong as a global financial center. He also pointed out that depriving Hong Kong of its special status would harm American companies and destroy investment cooperation with American companies. IP, IP IPO, the financial center of the world economy, while the protests act as one of the tools for the us to influence China in the struggle for economic leadership in the world [4, 7].

We believe that the Hong Kong state system should be reformed in order to play a greater role in promoting long-term economic development. As previously shown, Hong Kong's relations with the mainland are fundamental to determining its socio-economic fate, and the complementarity of these relations has brought

huge benefits. Successful cooperation with the mainland is used by the private sector in China and Hong Kong, and further integration requires the Hong Kong government to take critical measures. This would create huge opportunities for Hong Kong, as well as for the Chinese economy.

A concentrated service economy in Hong Kong may be fundamental to China's economy, where structural changes are helping to transform the future of Hong Kong into a full-fledged global center. Usually a growing economy spends more on services, and this is what is happening in China. The wide range of services that Hong Kong can offer to a growing population with increasing incomes will ensure profit and employment opportunities. This advantage of Hong Kong allows it to become a unique service center in China, where it will be easier for mainland residents to work. In today's world, the service sector is increasingly providing faster economic growth and higher productivity. Taking this into account and taking into account the large-scale changes taking place in China, we believe that Hong Kong can change the geopolitical and geo-economic status of China, which indicates the need to maintain its special position.

Conclusion

Summing up the research, we can conclude that the recent events related to the protests, as well as the reaction of the Chinese authorities to them, have shown that it is already necessary to work on an agreement after 2047. One option is to continue this period with the "soft" integration of Hong Kong into the PRC.

It is established that there may be several options for the development of events: maintaining and continuing the current status of the province as a special Autonomous region, partially abolishing autonomy by canceling local elections, or completely abolishing the special status of Hong Kong and turning it into a normal Chinese province. In our opinion, the most successful option for Hong Kong and China would be to further develop integration processes with mainland China and establish Hong Kong as an offshore trading center for the yuan, which is crucial for strengthening its status as a world-class financial center. In order to achieve complementarity, mainland China and Hong Kong should cooperate within the framework of intergovernmental coordination of both territories.

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俄罗斯联邦发展国内粮食援助
DEVELOPMENT OF DOMESTIC FOOD AID IN THE RUSSIAN FEDERATION

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抽象。根据俄罗斯联邦政府于2014年7月3日发布的第1215-r号命令，批准了俄罗斯联邦发展国内粮食援助的构想[1]。

就本概念而言，国内粮食援助应理解为是一种向俄罗斯联邦人口提供的国家援助系统，其形式是直接向有关方面提供粮食供应或为他们购买粮食提供资金以改善状况。营养并达到其平衡，同时考虑到合理的食品消费规范。

根据1999年7月17日第178-FZ号联邦法律"关于州社会救助"的规定[2]，针对低收入人群提供了有针对性的州社会救助，包括现金形式和食品形式家庭，低收入公民，根据俄罗斯联邦组成实体的规范性法律法规和州区域计划制定的其他类别的公民，但以牺牲俄罗斯联邦组成实体的预算为代价。此类援助的金额，提供条件和程序也由俄罗斯联邦组成实体的国家当局决定。食品直接交付给受益人或通过社交商店网络分发给公民。

另外，有需要的公民，特别是养老金领取者，残疾人，在社会服务机构的社会食堂和孤独老人的特殊住所中获得免费或优惠餐。

某些类别的公民，包括老年人，大家庭，有残疾儿童的父母，以及监护人，受托人，寄养父母和寄养者，都获得了免费分发的食品包。

在一些地区，已经向生活在困境中的人们购买食品和热餐（包括使用电子手

段）的公民引入了各种形式的货币补偿。

该概念的执行将由执行当局在既定权力的框架内，通过执行一项行动计划来实施，以发展俄罗斯联邦的国内粮食援助系统。

这项研究的目的是分析在俄罗斯联邦组织家庭粮食援助的可能性。

Abstract. By Order of the Government of the Russian Federation № 1215-r dated July 3, 2014, the Concept for the Development of Domestic Food Aid in the Russian Federation was approved [1].

For the purposes of this Concept, domestic food aid is understood to mean a system of state aid to the population of the Russian Federation in the form of direct food supplies to interested parties or the provision of funds for their purchase of food in order to improve nutrition and achieve its balance, taking into account rational norms of food consumption.

In accordance with the Federal Law of July 17, 1999 № 178-FZ "On State Social Assistance" [2], targeted state social assistance, including in the form of cash payments and in the form of food, is provided to low-income families, low-income citizens living alone, other categories of citizens in accordance with the normative legal acts of the constituent entities of the Russian Federation and state regional programs at the expense of the budgets of the constituent entities of the Russian Federation. The amount of such assistance, conditions and procedure for its provision are also determined by the state authorities of the constituent entities of the Russian Federation. Food is delivered directly to beneficiaries or distributed to citizens through a network of social stores.

Also, citizens in need, especially pensioners, disabled people, are provided with free or preferential meals in social canteens at social service institutions and at special homes for lonely elderly people.

Distribution received the provision of free food packages by certain categories of citizens, including senior citizens, large families, parents with disabled children, as well as guardians, trustees, foster parents and foster carers.

In some regions, various forms of monetary compensation have been introduced to citizens who find themselves in difficult life situations for the purchase of food and hot meals, including using electronic means.

The implementation of the Concept will be carried out by the executive authorities within the framework of the established powers through the implementation of an action plan for the development of the system of domestic food aid in the Russian Federation.

The purpose of this study is to analyze the possibilities of organizing domestic food aid in the Russian Federation.

Methods: comparative analysis; economic forecasting; sociological.
关键词：国内粮食援助，社会援助，农业生产，粮食供应，财政支持。

Among the factors that caused the accelerated adoption of the Concept for the Development of Domestic Food Aid in the Russian Federation was WTO membership.

As is known, the World Trade Organization has established the so-called "baskets" that determine the direction and amount of state support for agriculture. One of them is "green", which includes measures that do not have a negative impact on trade and production, and are not aimed at supporting producer prices. Among the areas of the green box are domestic food aid programs, the maintenance of strategic food stocks.

In practice, domestic food assistance is provided in the form of social food coupons or tickets.

The modern coupon system appeared in Europe, in the countries affected by the First World War. In the twentieth century, it was widely used in the countries of the socialist camp to combat commodity shortages, and in countries with a market economy - to support socially vulnerable groups of the population.

A voucher system for the least protected populations has long been in place in the United States. Food ration cards are America's social support tool. A food coupon is an electronic card replenished by the state from budget funds on a monthly basis.

The American Supplemental Nutrition Program, also known as the food ticket program, is a federal program to help people in the United States of America who have no or low income. The USDA program is in charge of the program [3].

We provide information about the United States in order to understand how in the WTO conditions it is possible to support domestic agriculture. It is clear that the amount of expenditures for state support of the agricultural sector in the Russian Federation in comparison with the United States is much less, but in this case we are talking about a legitimate economic mechanism that has a positive impact on the sustainable development of the country's agricultural sector using the WTO rules and regulations.

For an agricultural producer, one of the most important factors is the sale of manufactured products. And he really needs a guarantee from the state that these products will be purchased on time and the money earned will go to wages, taxes and replenishment of working capital.

Everything is clear in the USA, but how domestic food aid is developing in our country.

According to the information of the Ministry of Industry and Trade of the Russian Federation, by mid-April 2015, it was planned to prepare a model of the sys-

tem of food categories for citizens eligible for various subsidies. It was considered that the regions would be involved in the implementation of the program. It should be a support system not only for the population. It will also be aimed at the development of domestic agricultural production.

However, as is the case with the implementation of strategic concepts and plans, much of what is planned remains without the proper influence of the authorities and, therefore, is not communicated to the population.

True, in some regions they tried (Moscow, Kirovskaya oblast, etc.) to start organizing work on providing domestic food aid, but they did not succeed in mass character and consistency in this matter.

The existence of the Concept for the Development of Food Aid in the Russian Federation is not mentioned, in the Address to the Federal Assembly on January 15, 2020, President of the Russian Federation V.V. Putin, among other areas of social support for the population, proposed to provide hot meals for all primary school students from the first to the fourth grade [4]. This is a serious step in terms of providing domestic food assistance to the population of the country, especially children. At the same time, such a situation became possible only after the personal initiative of the President of the Russian Federation, and in a state governed by the rule of law, which, according to the Constitution, the Russian Federation is, such decisions must be formalized in the form of a federal law.

In the Federal Law and by-laws, it is necessary to build a system for providing social assistance or support to the country's population, clearly classifying the consumption of services by age, sex and social status, so that this social support is addressed to those who really need it.

As an example of the categories of citizens who can be provided with domestic food assistance, it is logical to cite the socio-economic approaches of Moscow, outlined in the draft law "On social nutrition in the city of Moscow" [5].

True, this law has not yet been adopted, but general approaches can be taken as a basis.

According to the draft law, the right to receive social food in Moscow is granted to the following categories of citizens:

- students of grades 1-4 of educational institutions that are engaged in general education programs;

- students from large and socially unprotected families in educational institutions engaged in general education programs;

- learners and students of state educational institutions of primary and secondary vocational education in full-time education;

- orphans and children left without parental care (legal representatives);

- students of state educational institutions "School of Health", studying in specialized and cadet classes;

- underage pregnant women and mothers, unborn children and young children over the age of 9 months;

- patients undergoing inpatient examination and treatment in all types of health care institutions in Moscow;

- disabled people and elderly citizens in stationary institutions (HTP, PNI, DDI);

- non-working pensioners, disabled people, veterans of the Great Patriotic War and labor from among the needy citizens of the city of Moscow;

- homeless citizens in social adaptation centers;

- foreign citizens with minor children, in respect of whom the court has made a decision on forced expulsion from the Russian Federation.

The development of such legal documents is welcome. However, it should be noted that this draft law of the city of Moscow is purely social in nature and he did not say a word about the main subject of all social relations - about the agricultural commodity producer. After all, if there is no food, then there will be nothing to distribute, guided by any socially significant and noble goals.

It should be noted that the draft of this law was prepared a long time ago and today it is necessary to include in its content those proposals of the President of the Russian Federation that improve the social situation of the population, especially children, the elderly, etc.

The adoption of the law "On domestic food aid" may be important for agricultural producers for whom an official market for agricultural and food products supported from the budget opens.

If we build an effective system for providing food assistance to the population of the country, then agriculture will have state guarantees for financial support for the sale of agricultural products.

Let's take the USA as an example. The US government, realizing social objectives, provides financial support to farmers and other categories of agricultural producers. The structure of US budget expenditures for support of agriculture for 2013-2023 looks like this on average:

Insurance - 6%

Secured lending - 16%

Food aid to the population - 78% [3].

Thus, through food aid to the population, farmers and other agricultural commodity producers in the United States annually receive more than $ 100 billion in income, with a total financing of agriculture of about $ 5 billion. There is a clear benefit to farmers from participating in this social program.

It should be noted that the provision of domestic food aid does not contradict the norms and rules of the WTO, which is just as important in terms of membership in this organization.

An analysis of the Concept for the Development of Domestic Food Aid in the Russian Federation, adopted on July 3, 2014, convinces us that five years ago the right decision was made to form and develop a system for providing domestic food aid to the population in the country and to develop for this purpose a potential market for the sale of agricultural food products by domestic producers.

Unfortunately, it turned out as always, the legal act was adopted, but work on its implementation was not carried out, as a result, the socially disadvantaged population and agricultural producers also suffer, who, if they are not in demand in the domestic market, master the export of food to the world agro-industrial market. It would be wrong to say that domestic food aid is not provided to the population of the Russian Federation at all, because there are all sorts of social insurance and other establishments for the provision of social nutrition or trade, for example, food sets for the poor. However, such events are carried out haphazardly, without linking with agriculture, therefore, both in nutrition and in trade there may be products of imported origin, which is not desirable for Russian farmers and other agricultural producers.

It is also important that in the case of a systemic organization of domestic food aid, agricultural consumer cooperatives (purchasing, marketing, processing, and others) supplying farmers' products to social organizations can develop.

Based on the experience of the United States in providing domestic food aid, a special organization system should be created on the basis of the Ministry of Agriculture of Russia to ensure the production and sale of food tickets (coupons), procurement under contracting agreements (Articles 535-538) of the Civil Code of the Russian Federation [6], registration of financial documents on state support for suppliers of food products and for the costs of social institutions providing services for domestic food assistance.

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考虑到功能目的，在多层印刷电路板结构中的层分布
DISTRIBUTION OF LAYERS IN THE STRUCTURE OF A MULTI-LAYER PRINTED CIRCUIT BOARD, TAKING INTO ACCOUNT THE FUNCTIONAL PURPOSE

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抽象。 PCB设计的关键点之一是多层PCB的分层。 如果这些层放置不正确，则印刷电路板中的电磁兼容性会下降，这可能会导致设备或整个产品运行出现故障。 在这方面，考虑到多层印刷电路板的功能目的，有必要铺设多层。
关键词：多层印刷电路板，印刷电路板结构，屏蔽，特性阻抗，微带，具有受控特性阻抗的传输线。

Abstract. One of the key points in PCB design is the layering of a multilayer PCB. If the layers are incorrectly placed, the electromagnetic compatibility in the printed circuit board deteriorates, which can lead to malfunctions in the operation of the unit or the product as a whole. In this regard, it is necessary at the design stage of a multilayer printed circuit board to lay layers taking into account their functional purpose.

Keywords: multilayer printed circuit board, printed circuit board structure, shielding, characteristic impedance, microstrips, transmission lines with controlled characteristic impedance.

Layer design should be done after preliminary layout. The preliminary layout will allow to take into account not only the distribution of heat-loaded elements on the printed circuit board, but also to clearly see the density of the signal lines in the board. Different parts of the PCB will have different signal line densities. After analyzing the area with the highest signal line density, you can calculate the number of signal layers. It is also necessary to analyze the components and set the smallest nominal size of the contact pads when assembling the elements, which will determine the accuracy class of the printed circuit board according to [1].

Knowing the number of signal layers, we will build the structure of a multi-layer printed circuit board, where design features will be taken into account with the addition of metallized layers.

First of all, we will place transmission lines with a control characteristic impedance in the inner layers of the printed circuit board to protect against external electromagnetic interference, the rest of the signal lines are located on the outer layers and the remaining internal ones.

Layers containing signal transmission lines with controlled characteristic impedance are placed between two metallized layers to shield them from other signal lines in the printed circuit board. We will use one of the shielded layers as a reference layer.

After the location of the signal and support (or shielding) layers, we select the material for the manufacture of the printed circuit board. As a rule, FR4 fiberglass is used. The properties of materials used for printed circuit boards and assemblies largely determine the electrical and physical parameters, as well as the characteristics of the finished product. The choice of materials for electronic modules operating at a frequency of more than 1 GHz is especially important [2].

For the manufacture of complex multilayer printed circuit boards, a material such as FR-4 (glass fiber epoxy laminated material) is used, in which the dielectric constant is $\varepsilon = 4.6$; there is also FR-1 material with a dielectric constant $\varepsilon = 5.2$. However, for the manufacture of digital high-speed printed circuit boards, a laminate with a relative dielectric constant of less than 3 and, if possible, with the smallest dielectric loss tangent is preferred [3].

Many base materials can also be used to fabricate high density PCBs using traditional processes for blind and internal vias. But today new materials have appeared that allow increasing the density through the use of special technological processes [4].

Figure 1 shows the dependence of the characteristic impedance of a microstrip line on various materials with different dielectric constants.

When choosing a material, the thickness of the metallized layer should also be taken into account. Then we calculate the geometric dimensions (width, gap) of the transmission line, taking into account the wave resistance and the parameters of the laid material. If, during the calculation, the line thickness meets the accuracy class higher than that calculated earlier on the component contact pads, then it is advisable to replace the material thickness to obtain the desired accuracy class so as not to complicate the design and reduce the cost of manufacturing the printed circuit board.
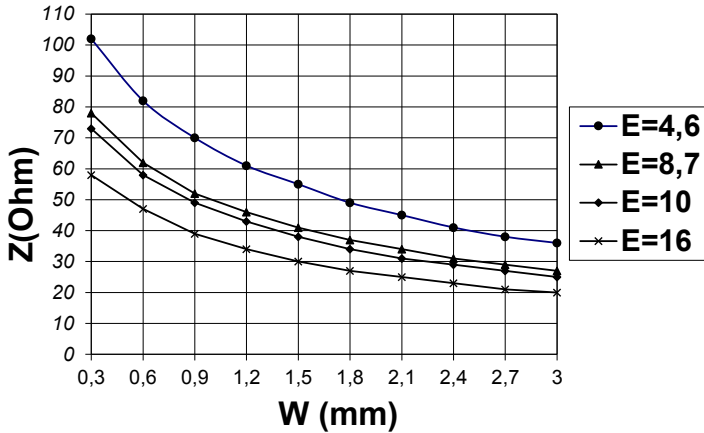
Figure 1 – Graph of the dependence of the wave impedance of a microstrip line on various materials with different dielectric constant

If there is a need to place transmission lines with controlled characteristic impedance on the outer layers of the printed circuit board, then when calculating the geometric dimensions, it is necessary to take into account the error introduced by the technological coating. Technological coatings introduce an error of up to 15% when calculating the width of transmission lines [5].

Figure 2 shows the distribution of layers in an eight-layer PCB considering EMC and heat dissipation. Where: Signal - signal transmission lines that do not require wave impedance control, and Signal (Z) - signal transmission lines with controlled wave impedance.

We use layers with solid metallization not only as shielding between signal layers, but also as heat distribution throughout the PCB.

When constructing a structure, in cases where both sides are used on one of the cores of the material, as metallized layers, it is advisable to lay the material with a foil an order of magnitude thicker. Layers 6 and 7 in Figure 2 refer to one material - FR4 glass fiber laminate metallized on both sides. In this situation, it is possible to lay the foil not 0.018 mm, but 0.035 mm. This will improve the shielding effect and heat distribution throughout the board.

Figure 3 shows the frequency dependence of the screening efficiency of a continuous metallized layer in an electromagnetic field.

Слой	Технологическое покрытие	толщина	материал	Назначение слоёв	Функциональное назначение
	Технологическое покрытие	0,03–0,05 мм	Лак (Поливоск)		
Слой 1	Фольга	0,018 мм	фольга 0,018	Signal+GND	Распределение сигнала, экранирование, рассеивание тепла
	Препрег	0,134 мм	1080/2 слоя		
Слой 2	Фольга	0,018 мм	стеклотекстолит FR-4 018/18/18	GND	Экранирование, распределение тепла
	Ядро	0,18 мм			
Слой 3	Фольга	0,018 мм		Signal (Z)	Распределение сигнала с контролируемым волновым сопротивлением
	Препрег	0,134 мм	1080/2 слоя		
Слой 4	Фольга	0,018 мм	стеклотекстолит FR-4 018/18/18	GND	Экранирование, распределение тепла
	Ядро	0,18 мм			
Слой 5	Фольга	0,018 мм		Signal (Z)	Распределение сигнала с контролируемым волновым сопротивлением
	Препрег	0,134 мм	1080/2 слоя		
Слой 6	Фольга	0,035 мм	стеклотекстолит FR-4 018/18/18	GND	Экранирование, распределение тепла
	Ядро	0,18 мм			
Слой 7	Фольга	0,035 мм		PWR	Экранирование, распределение тепла
	Препрег	0,134 мм	1080/2 слоя		
Слой 8	Фольга	0,018 мм	фольга 0,018	Signal	Распределение сигнала, экранирование, рассеивание тепла
	Технологическое покрытие	0,03–0,05 мм	Лак (поливоск)		

Figure 2 - Distribution of layers in the structure of a multilayer printed circuit board
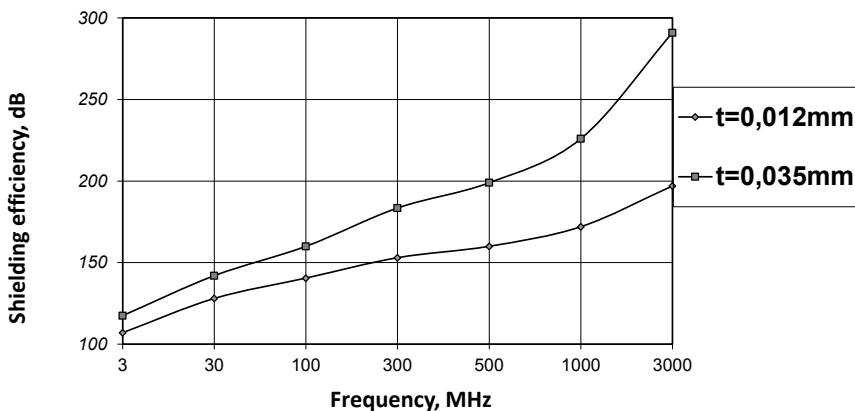
***Figure 3** – Frequency dependence of the screening efficiency of a continuous metallized layer in an electromagnetic field (t-foil thickness)*

After distributing the layers and calculating the geometric dimensions of transmission lines with controlled characteristic impedance, preliminary tracing of these lines should be performed and the heat distribution over the printed circuit board should be simulated taking into account the laid down metallized layers of different thicknesses.

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强大的风冷涡轮发电机的转子冷却效率
ROTOR COOLING EFFICIENCY OF A POWERFUL AIR-COOLED TURBOGENERATOR

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抽象。本文介绍了涡轮发电机转子空气冷却系统的计算。转子风冷系统具有自通风功能，其径向风道由副槽风道提供。本文中提出的数学模型反映了物理模型的所有重要几何参数以及冷却过程的气体动力学。估算了320 MW涡轮发电机的热交换效率。使用共轭传热计算进行研究。将结果与涡轮发电机投入运行的实验数据进行比较。在计算和实验数据之间获得了良好的一致性。结果表明，在从入口到子槽管道的第一条径向管道中观察到适度的涡流，并出现了从转子和发电机定子之间的缝隙回流的热空气。研究还表明，进一步研究子槽导管的轮廓可能会对均衡转子绕组沿其长度的温度产生重大影响。
关键字：有限体积法（FVM），跨学科任务，空气冷却系统的数值计算，转子，基于雷诺方程（RANS）的仿真，子槽和径向转子管道，涡轮发电机。

Abstract. This paper describes a calculation of a turbogenerator air-cooling system. The rotor air-cooling system has self-ventilation with radial ducts fed from sub-slot ducts. The mathematical model proposed in the article reflects all the significant geometric parameters of the physical model as well as the gas dynamics of the cooling process. The efficiency of 320 MW turbogenerator heat exchange was estimated. The studies were performed using conjugate heat transfer calculations. The results are compared with the experimental data of the turbogenerator into operation. Good agreement between the calculated and experimental data is obtained. It was shown that the moderate vortex formation is observed in the first radial ducts from the inlet to the sub-slot duct with the appearance of

heated air back flows from the gap between the rotor and the generator stator. Research has also shown that the further study of the sub-slot duct profile could have a significant effect on equalizing the temperature of the rotor winding along its length.

Keywords: *Finite volume method (FVM), inter-disciplinary tasks, numerical calculation of the air cooling system, rotor, simulation based on the Reynolds equations (RANS), sub-slot and radial rotor ducts, turbogenerators.*

Introduction

A characteristic trend of recent times is the heavier operating modes of power systems and the increasing complexity of their control [1], [2]. One of the topical trends in the development of power systems aimed at mitigating these problems is the use of gas turbines for power generation. The development of gas turbine technology force the demand for a powerful air-cooled turbo generators has increased rapidly in all over the world [3]-[5].

An important factor limiting a turbogenerator capacity is the heat up of its rotor winding. The principle of rotor winding self-ventilation with radial ducts fed from sub-slot ducts is a very well established cooling technique [6]. However, one of very well-known issues is actually the non-uniformity of the flow in the ducts and hence temperature distribution along the rotor. It is important to mention that in order to design the whole system successfully it is not enough to resolve the total gas flow rate problem that determines the average winding temperature. The reason is that radial and slot ducts with different designs produce notably varying temperature fields in the groove part of the rotor, despite the gas flow rate being the same.

In up-to-date rotor design, this unevenness is mitigated by means of using variable-section sub-slot ducts, but the effectiveness of this technique has not yet been sufficiently evidenced.

The main goal of this research is to evaluate the effectiveness of heat transfer in rotor winding through solving the conjugate heat transfer (CHT) problem.

A complicated task in the numerical evaluation of gas dynamics and heat transfer is to verify mathematical models of these processes. Usually, this requires data obtained in engineering mock-up experiments with modelled systems and constructions. In the article the results of the CHT solution problem were compared with experimental data on the air-cooled 320 MW turbogenerator into operation.

1. Heat exchange efficiency of the rotor turbogenerator

Research has been done into the temperature field of the rotor groove part of air-cooled turbogenerators with a variable (stepped) sub-slot ducts profile. With this aim, a CHT problem was solved in ANSYS Workbench [7]-[11]. The geometry of the stepped profile corresponds to the generator into operation and has three sections along the axial rotor length. Figure 1 shows the test rotor prototype with

variable sub-slot profile at the generator unit No. 3, Kashira Power Plant, and the sub-slot profile under review.
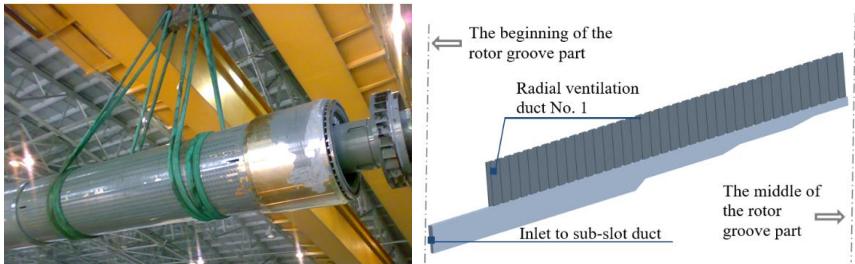
Fig. 1. *Rotor test prototype assembly on a 320MW turbogenerator and Investigated sub-slot duct profile*

1.1 *CHT Problem Method*

The geometric characteristics of the radial and sub-slot ducts of the turbogenerator under review are as follows: ½ of the rotor length 2450 mm, two-row radial duct arrangement, the number of radial ducts – 76, the ratio of the sub-slot duct section to the total area of radial ducts – 0.26; rotation speed – 3000 rpm. The numerical model shown in Figure 2 includes the air of the sub-slot duct and radial ducts; the rotor winding and ground insulation, and the rotor core.
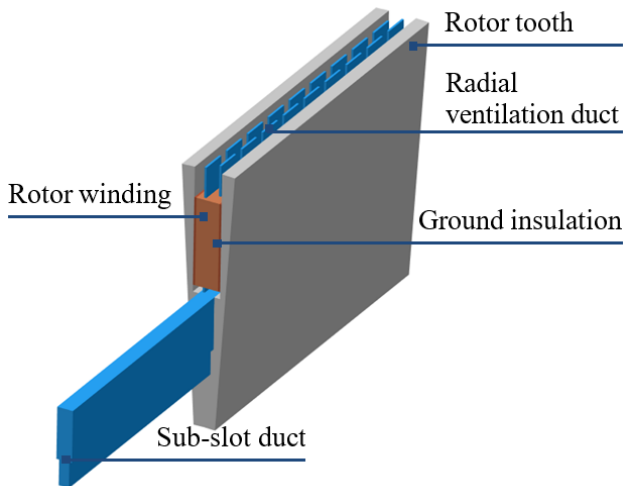
Fig. 2. *The geometry of the mathematical model for the CHT problems.*

The stationary problem is considered. On the surface of the inlet to the computational domain, the axial component of the velocity was calculated through flow rate, and the temperature was set at 40°C. The flow rate was calculated separately at the stage of the computational air dynamic simulation. At the outlet of the connecting area, the condition was found of air pressure equalizing with the surrounding air. Volumetric heat flux calculated for the rated load was specified as the heat source in the rotor winding. The rotor winding made up of isolated turns is presented as a solid bar anisotropic in thermal conductivity. The initial temperature of air and all the solids is set at 40 ° C. The main model parameters: volumetric heat flux is 0.69 MW/m³, thermal conductivity of the ground insulation is 0.26 W / m·K. Refinement $\sim 3 \cdot 10^6$ was used in the algorithm.

1.2 Verification of the Calculation

The experimental data of a 320 MW turbogenerator commissioning thermal test for several rotor current values done at Kashira Power Plant were used to compare the results of the numerical simulation with a variable sub-slot duct [12]. The average rotor winding temperature was determined from rotor resistance [13], [14]. The test showed that the rotor winding temperature average rise over the cold (inlet) air temperature was 57.0 °C at rated load. This experimental value is in good correlation with the calculated value of 52.9 °C.

1.3 Analysis of Results

The research was done to establish the correlation between the degree of the rotor winding temperature non-uniformity along the axial rotor length. The main findings are presented in Figure 3.
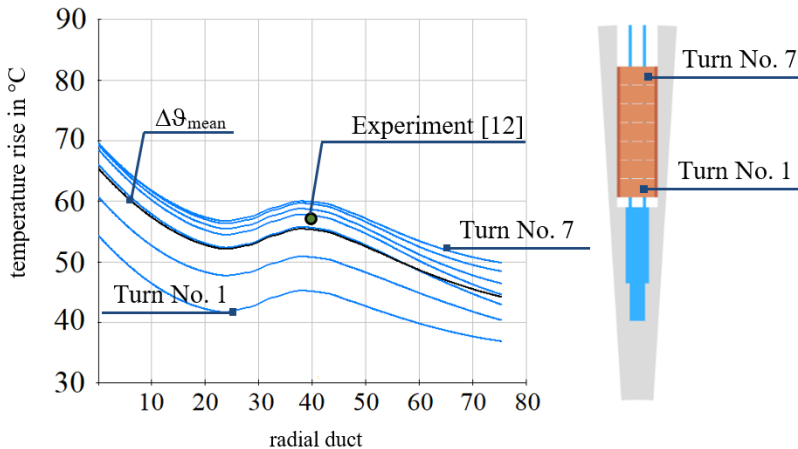
Fig. 3. *The temperature rise distribution of the turns of rotor winding above the cold (inlet) air temperature along the axial rotor length at rated power.*

In Figure 3, $\Delta\vartheta_{mean}$ is the average rotor winding temperature along the axial rotor length.

It was determined that the ratio of the maximum to the minimum velocity in the radial ducts is 2.85; air heat up in the first duct is 39.0 ° C, in the central one is 19.0 ° C; the maximum temperature of the rotor upper turn is 109.1 ° C. As could be seen from the distribution, the highest rotor winding temperature corresponds to the location of the first radial ducts. Figure 4 shows plots of the air temperature distribution and the velocity in the initial and central radial ducts. Moderate vortex-transformation is observed in the initial ducts with the possible appearance of a reverse air flow from the gap. At the same time, there is a unidirectional and sufficient aligned air flow in the central ducts.
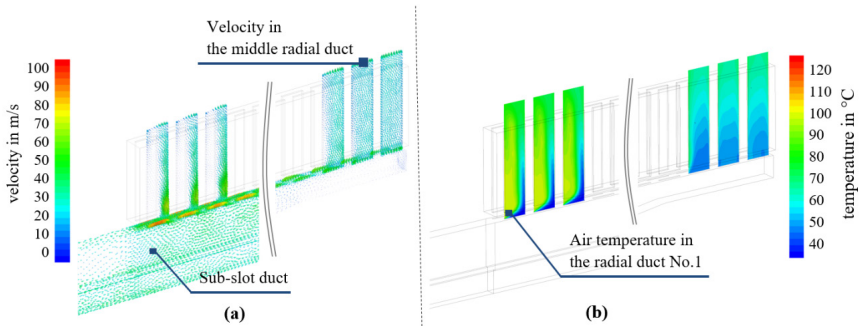
Fig. 4. *Velocity (a) and air temperature (b) in the initial and center radial ducts along the axial rotor length of turbogenerator at rated power.*

Conclusion

A method of numerical simulation of aerodynamic and thermal fields has been proposed that takes into account a real turbogenerator rotor construction and makes it possible to obtain detailed air velocity distributions and temperature of active and structural rotor components in the computational domain. The numerical simulation of the rotor groove part thermal condition is in good agreement with the results of a thermal test of the air-cooled 320 MW turbogenerator at a power station. Air velocity uniformity in the radial ducts is 2.85 and the maximum temperature of the upper turn is 109 ° C. It is shown that further study of the shape of the sub-slot duct could have a significant effect on the equalizing of the rotor winding temperature along its length.

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电专家–新的科学学科
ELECTROEXPERTOLOGY – A NEW SCIENTIFIC DISCIPLINE

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抽象。 本文专门介绍电专家。 该文章证实了科学界对电专家的需求。 揭示了其一些结构成分，并给出了其形成的特征。 电专家学被认为是一门新的科学学科和新的科学方向。 已经提出了22个新的快速公式，用于传导应用于电气网络的电气技术专业知识。 已经确定了电专家学的现状和发展方向。 可以得出合理的结论，即所提出的工作为电专家的科学基础的形成做出了一定的贡献。

关键字：电专家，电气工程专业知识的一般理论，电气工程专业知识，电气工程专业研究，电气工程专业知识的表达公式。

Abstract. *The article is devoted to electroexpertology. The article substantiates the demand for electroexpertology by the scientific community. Some of its structural components are revealed, the characteristics of its formation are given. Electroexpertology is considered as a new scientific discipline and as a new scientific direction. 22 new express formulas have been proposed for conducting electrical technical expertise as applied to electrical networks. The current state and promising directions of development of electroexpertology have been determined. A reasoned conclusion is made that the proposed work makes a certain contribution to the formation of the scientific foundations of electroexpertology.*

Keywords: *electroexpertology, general theory of electrical engineering expertise, electrical engineering expertise, expert research in electrical engineering, express formulas for electrical engineering expertise.*

Introduction

Relevance of the study. Are there any preconditions for the genesis and relevance of electroexpertology (hereinafter referred to as EEL) as a new scientific discipline? Yes, and there is the following justification for this. Currently, the Russian Federation has a developed network of expert institutions, whose numerous tasks include, among other things, conducting various kinds of electrical expertise.

Electrotechnical expertise is interdisciplinary in nature, and can be the subject of a separate discipline. In addition, one should take into account the essential role of electrical expertise in identifying the causes of various accidents at electric power facilities.

An analysis of scientific literature over the past 10-15 years has shown that there are no publications, except for the author's ones, devoted to EEL, that is, EEL is not yet an explored area. Therefore, the author made an attempt to gradually increase the volume of scientific research and scientific publications, the object of which is the theoretical problems of electrical engineering expertise. So, to date, he has published 16 scientific articles on theoretical problems of electrical engineering expertise in 7 countries, including in scientific journals from the list of the Higher Attestation Commission under the Ministry of Science and Higher Education of the Russian Federation, as well as in journals indexed in the international scientific citation databases Scopus and Web of Science. Since 2015, proposals to the author for publication on this topic have been received weekly from the editors of about 40 international scientific journals and publishing houses from 10 countries in Europe, Asia, America and Australia. In total, the author received about 180 proposals for the publication of scientific works, including from India, Germany and Belgium taken together - 120 proposals. Plus, the author receives similar proposals from the organizers of various Russian and foreign international scientific conferences. All this confirms the fact that there is a constant interest in EEL, and, therefore, as an independent theoretical system of knowledge, it is in demand in the scientific community. For this reason, according to the author, the proposed study is relevant.

Object of the study: general theory of electrical expertise (synonym - electroexpertology). *Subject of the study:* substantiation of the claim that EEL is a new scientific discipline that is currently in its infancy. *Purpose of the study*: if possible, cover those aspects of the EEL that would give the reader a general initial understanding of this new scientific discipline. *Research objectives* derive from the purpose of the research, and are reflected in its structure. *Structure of the study:* 1) the main structural components of the EEL; 2) the formation of the EEL; 3) express EEL formulas; 4) promising directions for the development of EEL; 5) scientific novelty and research results; 6) conclusion. *Research methods.* As a means to achieve this goal, the author applied the following well-known methods of scientific research: procedures of idealization and abstraction, as well as universal methods of cognition - analogy and comparison, analysis and synthesis, induction and deduction, the method of formalization.

1. The main structural components of electroexpertology

Definition of EEL. Electroexpertology - is a general interdisciplinary applied technical theory about the patterns and methods of formation and development of

the scientific foundations of electrical expertise. At the same time, the EEL serves as a methodological basis for various electrotechnical examinations. *Foundation of EEL* are the following disciplines: expertology, mathematics, systems analysis, electrophysics, electrical engineering, power engineering. *Object of EEL:* electrotechnical expertise and expert activity in the field of electrical engineering and power engineering. *Subject of EEL:* identification of patterns and theoretical constructions in the field of expert research on various aspects of electrical engineering and electric power engineering, methods of these constructions, implementation of expert research in practice.

Orientation of EEL: scientifically based application of specialized expertise in electrical engineering and power engineering. *Objectives of EEL:* 1) identification of the forms and tendencies of the manifestation of patterns during expert research in electrical engineering; 2) development of scientific methods, methods, approaches, algorithms, models and techniques for conducting electrical examinations; 3) service with the help of scientific knowledge expert activities in electrical engineering and electric power engineering; 4) the formation of a methodology for expert knowledge and the development of recommendations to improve the quality of expert opinions on electrical and power engineering facilities. *Tasks of EEL:* 1) implementation of the EEL objectives formulated above; 2) accumulation, analysis and synthesis of empirical material related to electrical engineering expertise, which is necessary to improve the EEL; 3) taking into account errors in the practice of conducting various electrotechnical examinations to optimize expert activities; 4) identifying trends and needs of the practice of conducting expert research in the industry, and taking them into account when building and developing prospects for the development of the theory of electrical expertise.

Functions of EEL as an interdisciplinary theory: 1) cognitive (epistemological): identifying the essence, nature of EEL; 2) heuristic: the discovery of patterns of formation, functioning and development of EEL; 3) educational: creating a base for EEL as an academic discipline; 4) methodological: development of EEL concepts and categories. *Methods of EEL*: 1) express methods; 2) techniques, principles, rules; 3) general scientific methods (analysis and synthesis, induction and deduction, systemic method and others); 4) private scientific methods used in electrical disciplines and in related sciences and scientific areas - in physics, mathematics, expertology, energy, economics, heat engineering, mechanical engineering, materials science, technology, informatics, design, modeling, systems analysis and others. *Requirements for EEL:* 1) reliability, verifiability in practice; 2) consistency; 3) logicality, coherence; 4) the ability to explain the essence of phenomena, to reveal their patterns. *The place of EEL in the system of sciences.* EEL refers to the subject applied sciences of subject matter cognition, and is part of electrical engineering.

Relationship of EEL with other sciences. By its nature, EEL is an integral interdisciplinary theory, and is built on the basis of electrical engineering and expertology. *Directions of EEL:* examination of power plants and substations, electrical networks and systems, relay protection and automation, static and dynamic stability of power systems, electrical loads and technical and economic calculations, electrical safety and electromagnetic compatibility; reliability of power supply and the quality of the adopted design electrical solutions. *Patterns of EEL*: 1) the patterns of work with the initial data and applied methods, not limited only to electrical engineering, during electrical examinations; 2) patterns of relationship between EEL and private expert theories of electrical engineering (which have yet to be developed); 3) patterns reflecting the methodology for the construction and development of scientific foundations and particular theories of electrical expertise; 4) the patterns of formation of various types of expertise in electrical engineering and power engineering; 5) the patterns of the process of expert research in the field of electrical engineering, obtaining its results; 6) patterns that provide knowledge of the essence of expert activity in the electrical industry.

Of course, this limited article does not cover all the structural components of the EEL. More details about its categories can be found in the publication [1].

2. Formation of electroexpertology

The first scientific publication about EEL (authors - OA Zhukov, V.Ya. Ushakov) appeared on January 25, 2013 in the journal "Bulletin of the Tomsk Polytechnic University" (volume 322, № 4, p. 82-87). Since then, a number of aspects of EEL have been developed by the author personally, as well as in co-authorship with his supervisor - Doctor of Technical Sciences, Academician, Professor of Tomsk Polytechnic University Vasily Yakovlevich Ushakov. These aspects are reflected in many scientific publications published in Russia, Turkey, Romania, Germany, Iran, India, Malaysia. To date, the following aspects have been developed regarding EEL: 1) approaches, express methods and express models, technique, methodology, concept, theoretical provisions; 2) the relationship of EEL with digitalization, intellectualization, expert systems in the electric power industry, with mathematical constants. The general theory (in the classical sense of this term) of electrical examinations has yet to be developed, but the main provisions of its concept, various aspects, components and features are reflected in the author's works, the titles and annotations of which can be found by clicking on the link: https://orcid.org/0000-0001-5316-9035. The beginning of the formation of EEL was laid by the integration (unification) of two well-known scientific disciplines - electrical engineering and expertology. It should be borne in mind that EEL differs from expertology and electrical engineering in grounds, object, subject and purpose [2, p. 54].

Is EEL an independent scientific discipline? Yes, since any scientific discipline is a system of knowledge that is focused on researchers and has the following characteristics: 1) problems and principles; 2) goals and objectives; 3) object and subject; 4) structure and function; 5) conceptual apparatus and categories; 6) concept and methodology; 7) methods and techniques; 8) approaches and features; 9) logical structure and patterns; 10) verifiability of results. All of the listed features are present in the EEL, therefore the EEL has every right to be considered as a binary (double) interdisciplinary scientific discipline, as well as the right to take an independent place in the structure of electrical disciplines with which it has close relationships.

Is EEL a science area? To answer this question, let us refer to the source: "A scientific direction can be understood as a formed part of a separate science (scientific specialty) developed by at least one scientist, the scientific product of which is a scientific doctrine. As a rule, doctrine is understood as a set of theoretical views (hypotheses) of at least one researcher in at least one research area. If in any doctrine there is at least one proven hypothesis (theoretical construction), then we can assume that such a doctrine has the property of scientific character "[3, p. 30]. Judging by this definition, proposed by the doctor of sciences, the author of more than two hundred scientific papers on expert activity, Anatoly Vasilyevich Nesterov, EEL is a scientific direction and scientific doctrine, since it contains all the listed features, including a proven hypothesis [4, p. 6].

3. Express formulas of electroexpertology

The table below shows 22 express formulas developed by the author that can be used in the examination of design parameters for electrical networks. To check the correctness of the formulas, it is enough to substitute in any of them the numerical values given in parentheses in the column "Designations".

Table. *Formulas of electrotechnical express-expertise*

Designations	Formulas
L – power transmission distance, km (100); U – power transmission voltage, kV (220); $S_{trans.s}$ – the apparent power transmitted from the generators to the power plant high voltage switching substation, excluding losses in power plant step-up transformers, MVA (150.13); ΔS_s – the apparent power losses in power plant step-up transformers, MVA (11.13);	$L = \dfrac{0,21U^2}{P_{trans.s}\cos\varphi_{PL}}$
	$U = \dfrac{I_{max.rated.pl}L\cos\varphi_g}{132}$
	$S_{trans.s} = \dfrac{1,25\times10^{-4}s^2_{economic}L}{n^2}$
	$\Delta S_s = \dfrac{1,8\times10^{-2}U^2}{\cos\varphi_g L}$

$S_{PL.s}$ – the apparent power transmitted from the generators to the power plant high voltage switching substation, taking into account the losses in power plant step-up transformers, MVA (139);	$S_{PL.s} = \dfrac{0{,}93 P_{trans.s}}{\cos \varphi_g}$
	$S_{PL} = 0{,}12 \Delta U P_{trans.s} n_{circuits}$
S_{PL} – the apparent power transmitted from the power plant high voltage switching substation to the main step-down substation, taking into account the losses in power lines, MVA (138.27);	$\Delta S_{PL} = \dfrac{5{,}2 \times 10^{-7} I_{max.rated.pl}^2 L}{\Delta U}$
	$Z_{PL} = \dfrac{10^{-3} I_{max.rated.pl} L^2}{U}$
ΔS_{PL} – the apparent power losses in power lines, MVA (0.727);	
Z_{PL} – full electrical impedance of power lines, Ohm (16.23);	$X_{PL} = \dfrac{4{,}1 \times 10^{-9} I_{max.rated.pl}^2 L^2}{\Delta P_{PL}}$
X_{PL} – the full inductive impedance of power lines, Ohm (13.3);	$R_{PL} = 1{,}2 \sqrt{\dfrac{UL}{I_{max.rated.pl}}}$
R_{PL} – the full active impedance of power lines, Ohm (9.3);	$P_{trans.s} = \dfrac{0{,}76 U \Delta U}{X_{PL}}$
$P_{trans.s}$ – the active power transmitted from the generators to the power plant high voltage switching substation, excluding losses in power plant step-up transformers, MW (120.1);	$\Delta P_{PL} = 5 \times 10^{-6} UI_{max.rated.pl}$
ΔP_{PL} – the active power losses in power lines, MW (0.41);	$Q_{trans.s} = \dfrac{1{,}94 \times 10^{-2} U^2 \Delta U}{L}$
$Q_{trans.s}$ – the reactive power transmitted from the generators to the power plant high voltage switching substation, excluding losses in power plant step-up transformers, MVAr (90.1);	$\Delta Q_{PL} = \dfrac{4{,}1 \times 10^{-9} I_{max.rated.pl}^2 L^2}{R_{PL}}$
	$n = \dfrac{I_{max.rated.pl} L}{55 U}$
ΔQ_{PL} – the reactive power losses in power lines, MVAr (0.59);	$\Delta U = \dfrac{70{,}5 X_{PL}}{L}$
n – the number of wires in each phase of PL, pcs. (3);	
ΔU – voltage loss in power lines, kV (9.6);	$\cos \varphi_g = \dfrac{535 P_{trans.s}}{I_{max.rated.pl} U}$
$\cos\varphi_g$ – the active power factor of the power plant generators (0.8);	$s = \dfrac{0{,}8 s_{economic} L}{U}$
s – section of one wire conductor for each of the three phases of the power line, mm² (120);	$\cos \varphi_{PL} = \left(\dfrac{152 U}{I_{max.rated.pl} L} \right)^2$
$\cos\varphi_{PL}$ – the active power factor of the power line (0.85);	
$n_{circuits}$ – the number of circuits in the power line (1);	$n_{circuits} = \dfrac{0{,}25 U^2}{P_{trans.s} L}$
$I_{max.rated.pl}$ – maximum rated current in the power line, A (365.2);	$I_{max.rated.pl} = \dfrac{287}{\cos \varphi_{PL}} \sqrt{\dfrac{P_{trans.s}}{L}}$
$S_{economic}$ – the economic section of a *three-core* wire for each of the three phases of the power line, mm² (332).	$s_{economic} = \dfrac{2{,}7 I_{max.rated.pl}}{n}$

Note for the table:

1. In parentheses given after the explanation of each parameter, numerical values from the design example are given [5, p. 7-8, 12-13]. Using this example, the author checked for reliability all 22 proposed mathematical formulas designed to calculate the values of the parameters of power lines in a steady state. The calculation error for these formulas is within ± 2%.

2. The proposed formulas are not related to differential and integral calculus, since under normal steady-state conditions the problem of determining the rate of the processes in the electric circuit is not posed. For this reason, it is sufficient to use linear static mathematical models in algebraic form [6, p. 27].

4. Perspective directions of development of electroexpertology

The author believes that the further development of EEL can be obtained by conducting research in the following areas: 1) development of new express methods, express models and techniques for assessing the correctness of the calculations in electrical projects; 2) development of a number of particular theories of electrical engineering expertise, methodologically related to the general theory of electrical engineering expertise (EEL); 3) search and isolation of what is common, which is characteristic of any objects during electrical examination; 4) search, analysis, assessment of existing EEL problems and ways to solve them; 5) deepening the relationship of the EEL with the particular theories of electrical engineering expertise and with scientific disciplines that are related to electrical engineering and electric power engineering; 6) improving the classification of electrical expertise; 7) search and analysis of patterns in the conduct of electrical expertise; 8) filling the structure of EEL as a general theory with the following components, and, accordingly, their development: foundations (empirical, initial, derived, semiotic, proto-theoretical, methodological), theoretical scheme, laws and regularities, mathematical and conceptual (conceptual-categorical) apparatus; 9) the gradual accumulation and systematization of the knowledge base on theoretical problems, concepts, methodology, methodology, methods of conducting electrical examinations to the extent that will allow EEL to rise from the level of praxeology aimed at effective and correct activity to the level of a full-fledged science.

5. Scientific novelty and research results

The conducted research has scientific novelty and makes a certain contribution to electrical engineering, since it reveals a number of aspects of EEL as a new scientific discipline and as a new scientific direction, indicating promising directions for its development. The novelty of the research is also manifested in the fact that it offers 22 new electrical express formulas for use in the examination of the calculated parameters of electrical networks in a steady state.

6. Conclusion

The proposed work makes a certain contribution to the formation of the scientific foundations of electroexpertology as a new independent scientific discipline

within the framework of theoretical electrical engineering. The author is confident that this work and his already published works on this topic are of scientific significance, since they lay the foundation for the development and systematic discussion of a set of problems, topics and questions on the general theory of electrical engineering expertise, and also create conditions for the development and solutions problematic situation in this area. The work is addressed primarily to those who are interested in theoretical problems of electrical engineering and expert research.

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研究城市间区域内路线的乘客公路运输的可用性
RESEARCH OF THE AVAILABILITY OF ROAD TRANSPORT OF PASSENGERS ON INTERMUNICIPAL INTRAREGIONAL ROUTES

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抽象。 在奥伦堡州进行的城市间客运量研究的基础上，开发了一种评估路线运输网络可用性的方法。 主要指标是路线运输网络密度的内部系数，路线运输网络密度的过渡系数，路线运输网络密度的一般系数和路线的长度。 建立了影响或与奥伦堡州城市间客运量的选定指标值相关的因素。
关键词：公路运输，客运，市际路线，运输服务质量，交通可达性指标。

Abstract. On the basis of the study of inter-municipal passenger traffic carried out in the Orenburg Oblast, a methodology for assessing the availability of the route transport network has been developed. The main indicators are the internal coefficient of the density of the route transport network, the transit coefficient of the density of the route transport network, the general coefficient of the density of the route transport network and the length of the route. The factors influencing or correlating with the values of the selected indicators of the availability of intermunicipal passenger traffic in the Orenburg Oblast are established.

Keywords: *road transport, passenger traffic, inter-municipal routes, quality of transport services, indicators of transport accessibility.*

Public road transport in intercity passenger traffic today plays an important role. This has become especially relevant at the present stage, when there is a cancellation of a number of suburban electric trains (at a distance of less than 200 km) and/or replacement of previously existing routes with shorter ones. Thus, improving the quality of intercity passenger transportation by road is becoming one

of the priority areas for work.

The purpose of the research work is to improve the quality of passenger transportation by road on intermunicipal routes in Orenburg Oblast using the assessment of indicators of the availability of transport services for the population. The objectives of the study are to develop criteria for assessing the quality of passenger transportation by road on intermunicipal regular routes, and to study inter-municipal passenger transportation by road from the standpoint of quality assessment criteria.

The research method used in the work can be characterized as a set of techniques, including regression analysis, factor analysis, methods of continuous systematic research.

The need to ensure the safety and high quality of services for the transportation of passengers is due not only and not so much to the establishment of such a goal in the relevant regulatory legal acts, but also to the actual circumstances of such transportation [5, 6]. This can be achieved, among other things, by establishing certain indicators of the quality of passenger traffic in regulatory enactments of various levels.

Federal legislation presupposes the possibility of establishing sectoral regional standards for the quality of transport services for the population along regular municipal and intermunicipal routes of motor transport [2, 4]. Some regions have adopted such regional standards in one form or another, developing their systems of quality indicators based on the Social standard of transport services for the population in the carriage of passengers and luggage by road and urban land electric transport, approved by order of the Ministry of Transport of Russia № NA-19-r dated 31.01.2017.

Due to similar conditions, including climatic ones, for the purposes of this study, the Sectoral regional standards for the quality of transport services to the population were used on regular municipal and intermunicipal routes of public motor transport in the Republic of Tatarstan (hereinafter - the Sectoral regional standards).

The indicators of the availability of the transport system include the route coefficient, the coefficient of network density and the transport mobility of the population (Table 1).

Table 1 - *Indicators of the availability of the transport system*

Availability indicator	Unit of measurement	Formula for determining the indicator	The value of the indicator established by the Industry Standard for the inter-municipal and municipal bus network
Route coefficient (K_M)	km/km	$$K_M = \frac{L_M}{L_c}$$	$K_M > 1{,}2 \div 1{,}3$
Network density factor (δ)	km/km²	$$\delta = \frac{L_c}{F_{сети}}$$	$\delta > 0{,}6 \ldots 0{,}8$
Transport mobility of the population (B)	travel units	$$B = \frac{Q_{год}}{N_{жит}}$$	$B > 5 \ldots 10$
where L_M - total length of routes, km; L_c - total length of roads within the network, km; F_{net} - network area - the area of the municipal district, km²; Q_{year} – annual traffic volume, pass.; N_{pop} – population living in the territory of the municipality, people.			

To assess the indicators of transport accessibility for various municipalities, two types of routes were identified, passing through these territories:

- internal routes - intercity/intermunicipal routes passing through the territory of only one municipal district, included in the route register, planning document or tender documentation (if the route network is under development or amending) for the conclusion of transportation contracts in this area;

- transit routes - intercity/intermunicipal routes passing through the territory of at least two municipal districts, included in the Register of intermunicipal regular transportation routes of Orenburg Oblast (as well as a regional planning document).

Thus, in the future, based on this classification of routes, the following types of indicators were used:

- internal/intra-municipal indicators - the total length of internal routes and the internal coefficient of density of the route transport network - indicators calculated on the basis of data on routes passing through the territory of one district, from the above regulatory documents of this district. Calculated for each region.

- transit indicators - the total length of transit routes and the transit coefficient of the density of the route transport network - indicators calculated on the basis of data on transit routes included in Oblast's register of inter-municipal routes. It is calculated for each region, the calculation includes the part of the route length passing through the territory of this region.

- general indicators - the total length of transit and internal routes and the general density coefficient of the route transport network - indicators characterizing all routes, both internal and transit in the part in which they pass through the territory of the region.

Orenburg Oblast includes 35 districts, 12 cities and 1 closed administrative-territorial unit Komarovsky. Cities are natural "centers of gravity" of the population (V.A. Gudkov, in particular, writes about the tendency of settling near the centers of gravity of interest to the population), so it seems logical to single out the districts on which the cities are located (or, as in the case of Orsk and Novotroitsk the territory of which the corresponding urban districts adjoin).

On the basis of Oblast registry data, two types of rural (i.e., not having a city on their territory) areas can be distinguished:

1. The so-called "transit" areas, through which the routes pass, which continue outside the territories of these areas (hereinafter referred to as transit routes);

2. Rural areas, on the territory of which there are no other intermunicipal routes than those that end in this rural area, or the share of such routes in the area is relatively small.

However, this classification is highlighted on the basis of formal characteristics, without taking into account the actual movements of Oblast's population.

Subsequently, on the basis of the experimental data presented, in particular, the values of the density coefficients of the transit and internal route transport network, the specified classification took the following form:

1. Districts-centers of gravity, "urban" areas (7 districts on the territory of which the largest cities of the Orenburg Oblast are located, which have the greatest "gravity");

2. Transit areas and areas with small centers of gravity (13 areas);

3. Rural areas (15 districts).

On the territory of Orenburg Oblast, the Register of intermunicipal routes of regular transport is kept, according to which, in Orenburg Oblast, intermunicipal transportations are carried out on more than 200 routes [1, 3].

The area of the Orenburg Oblast is 124,000 km^2.

The total length of inter-municipal routes, according to the Register data, is 30,770.1 km.

The density coefficient of the network of inter-municipal passenger routes of Orenburg Oblast included in the Register is 0.25 km/km^2.

The density coefficient of the network of intra-municipal routes is 0.13 km/km^2.

The overall density coefficient of the network of inter-municipal routes of the Orenburg Oblast, thus, is 0.38 km/km^2.

Work has been carried out to collect and systematize information on regular routes of passenger transportation of the Oblast within the municipalities, and information has been obtained on all municipal districts of Orenburg Oblast.

Figure 1 - *The length of the total bus transport network in the municipal districts of Orenburg Oblast (km)*

On the basis of the study of inter-municipal passenger traffic carried out in the Orenburg Oblast, a methodology for assessing the availability of the route transport network has been developed. The main indicators are the internal coefficient of the density of the route transport network, the transit coefficient of the density of the route transport network, the general coefficient of the density of the route transport network and the length of the route. The factors influencing or correlating with the values of the selected indicators of the availability of intermunicipal passenger traffic in Orenburg Oblast have been established, namely:

1. The length of routes and the density coefficient of the route transport network in municipal areas in which cities are present are more dependent on the population than on the area of the district;

2. The length of routes and the density coefficient of the route transport network in transit municipal areas almost equally depend on the area and population of the district;

3. The length of routes and the density coefficient of the route transport network in municipal districts, in which there are no cities, almost equally depend on the area and population of the district;

4. At the same time, when studying rural areas without dividing them into transit and "non-transit" route lengths to a greater extent depends on the area of the district, a much weaker dependence of the density coefficients of the route transport network on the number and density of the population was revealed.

The deduced patterns received experimental confirmation.

The study of the availability of intraregional inter-municipal routes for passenger transportation in Orenburg Oblast was carried out for the first time. The obtained values of the indicators of the availability of the route transport network can be used to develop regulatory documents for assessing the quality of transport services for the population.

Thus, in the course of the study, a method was developed for assessing the density of the route transport network of the municipal district, as well as the length of routes in this area, which makes it possible to use the research results when solving the problems of developing intercity transportation both in the Orenburg Oblast and in other subjects of the federation with similar natural -climatic and socio-economic conditions.

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高熵涂料的工业测试
INDUSTRIAL TESTING OF HIGH-ENTROPY COATINGS

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Introduction

In this work, which is a continuation of work [1], the mechanical properties of industrial coatings are considered. To obtain a magnetron target CrTiNiZrCu by mechanical alloying, micropowders of the corresponding metals were taken and mixed in equiatomic proportions [2, 3]. The coatings were applied on carefully polished samples on an NNV 6 setup with a magnetron target.

Beats of coal mills

Hadfield steel is a steel with a high manganese content (11-14.5%), as well as containing carbon (0.9-1.3%). The recipe for making this steel was proposed at the end of the 19th century by R. Gutfield. This steel is of austenitic class, it is not magnetic, after quenching it has an austenitic structure, hardness 250 HV. Hadfield steel has a unique combination of increased wear resistance with high ductility and toughness. Under the influence of dynamic loads, under the influence of cold deformation, its self-strengthening occurs. When parts made of Hadfield steel work under conditions of significant pressure and shock loads that cause work hardening, its wear resistance and hardness increase significantly (up to 600 HV) [4-6].

The main problem in the operation of coal grinding mills is the high abrasive wear of the beaters, the service life of which averages 500 hours. In this work, an attempt is made to increase the service life of the beaters of coal-grinding mills by mechanically activating them in a tumbling drum, followed by the application of strengthening high-entropy coatings.

The achieved level of abrasive (K_a) and shock - abrasive (K_{u-a}) wear resistance of manganese alloys in comparison with steel 110G13L is given in table. 1. To ex-

pand the comparison base in table. 1 also shows data on wear resistance for steels Kh12F1 and 75KhGSF (the latter is analogous to 75G2F). From the data table. 1 it follows that the structural characteristics of manganese alloys No. 1–3 do not provide a significant increase in the level of wear resistance in comparison with steel 110G13L.

The highest level of K_a and K_{u-a} is characteristic of $Cr_{12}F_1$ steel. However, this steel contains such scarce elements as chromium and vanadium in its composition, which complicates its widespread use. Consequently, in the case of the development of more economical alloying options to increase the wear resistance of steels, more attention should be paid to the dispersion-composite component of their strengthening.

Table 1 - Achieved levels of relative wear resistance of alloys [4-6].

| №	Alloy grade	K_a	K_{u-a}
1	120G2S2T	1,35	1,04
2	120G10FTL	1,48	1,40
3	130G7TL	2,10	-
4	220Cr2G4	2,80	0,60
5	H12F1	4,70	1,47
6	75HGSF	2,70	1,35

Hadfield steel was manufactured at Power Beton LLP in Karaganda by casting molten steel in an electric furnace. The initial hardness of high-manganese steel depends mainly on the content of carbon and residual carbides in it and after heat treatment amounts to HV 179-230. During the operation of castings under the influence of dynamic or significant specific static loads, their working surfaces are hardened (hardened), as a result of which the metal hardness increases to HV 500. The type of finished castings is shown in Fig. 1 a, and the hardness is in Fig. 1 b.

a)   b)
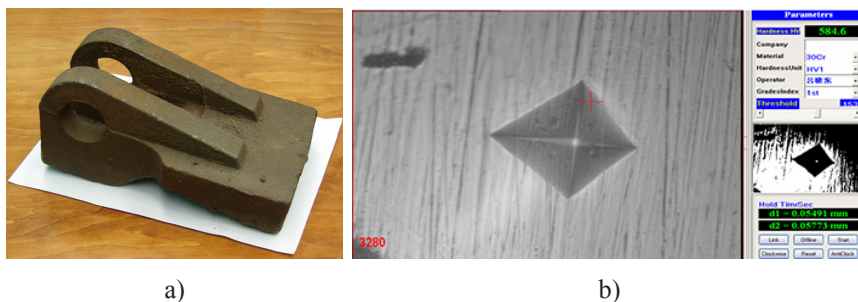
*Figure 1 - Beater of a coal grinding mill (a) and microhardness (b)*

The main type of rejects of high manganese castings is hot and cold cracks and they usually account for over 77% of the total number of rejects. We propose to knock out high-manganese castings from the molds only after the temperature of the most heated sections drops to 400 °C. It was found that the determination of the optimal duration of holding in the form of beaters of a coal-grinding mill for the purpose of knocking them out at a temperature of 400 ° C made it possible to reduce the marriage by cracks by more than three times (Fig. 2).

Despite the large number of works devoted to 110G13L steel, there is still no unified theory of its self-strengthening under shock loading. According to a number of authors, block refinement and microstresses play an important role in strengthening 110G13L steel. The high toughness of austenite, along with sufficient strength and wear resistance, makes 110G13L steel an irreplaceable material for parts that work for wear and shock at the same time. In abrasive wear, when there is no pressure and, consequently, no hardening, 110G13L steel does not have significant advantages in terms of wear resistance over other steels of the same hardness.
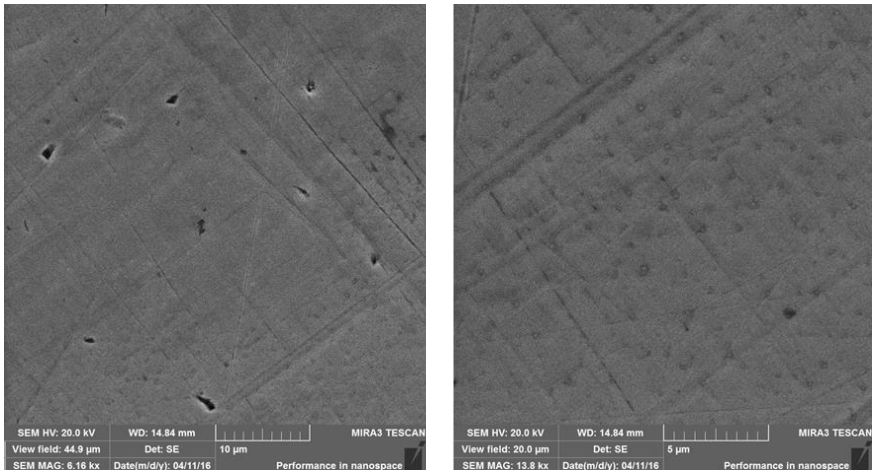
Figure 2 - SEM - beat image at 10 and 5 nm resolution

The wear of the Hadfield steel used at TPP-3 takes 500-550 hours of continuous operation. The wear rate is shown in fig. 3 a, and with a coating - in Fig. 3 b.

а)   б)
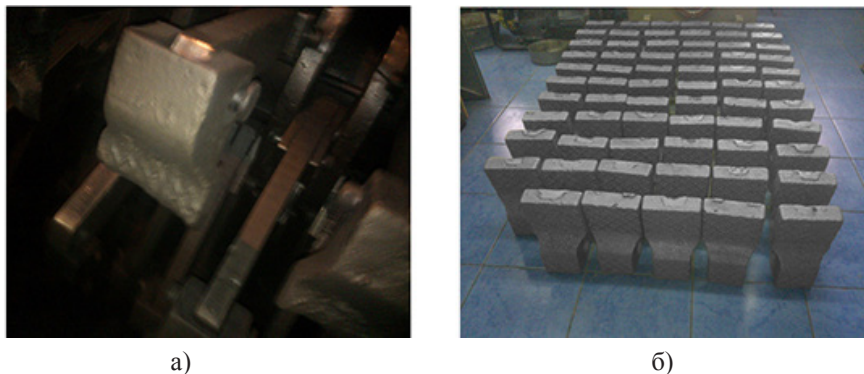
Figure 3 - *Wear and tear at the TPP (a) and CrNiTiZrCu coating (b)*

CrNiTiZrCu coated blades have the following properties:
- microhardness increases by about 1.6 times;
- wear resistance increases by 7.5 times;
- the coefficient of friction is reduced by almost 20 times!

The formula obtained by us shows that the work of destruction of the beaters of a coal-grinding mill is highly dependent on the coefficient of friction of the coating. The wear of Hadfield steel occurs in 500-550 hours of continuous operation. That is, after the high-entropy coating of CrNiTiZrCu, the resource beat of the coal mill increases almost 3 times (1600 hours), which is very significant economically.

Industrial tests of turbine blades. Scapular mechanisms are quite often used in units for various purposes. They are often used in turbines and compressors. The turbine is a rotary engine powered by centrifugal forces. The main working body of the machine is the rotor, on which the blades are fixed along the entire diameter. All elements are placed in a common body of a special shape in the form of injection and delivery pipes or nozzles. A working medium (steam, gas or water) is supplied to the blades, driving the rotor [7].

The turbomechanical plant in Karaganda mastered the blades for a steam turbine T - 100/120-130-2 TMZ made of steel 20Cr13 It is a single-shaft three-cylinder unit with two heating steam extractions (upper and lower) and two exhausts. Table 2 shows the chemical composition of steel 20Cr13 and its use with a long service life at temperatures up to 500 °C; steel of martensitic class.

*Table 2 -* *Chemical composition of steel 20Cr13*

C	Si	Mn	Ni	S	P	Cr	Fe
0,16 - 0,25	0,6	0,6	0,6	0,025	0,03	12 - 14	~84

International Conference

We first describe the application of titanium nitride coatings to turbine blades. During the coating process, constant temperature control is required. When the temperature drops from 450 °C to 420 °C, it is necessary to increase the temperature by short-term increase in the reference voltage to 1000 V. The duration of the coating is 2 hours. For the given spraying parameters, the coating thickness is 10-12 microns. As a result, the turbine blades have the form of titanium nitride coatings (Fig. 4).
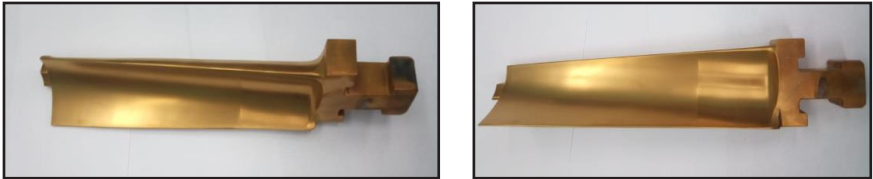
Figure 4 - Turbine blades with titanium nitride coating

In fig. 5 shows the results before the coating of titanium nitride on a sample of steel 20X13 (a) and after coating (b). The same results are reflected in table. 3. From the table. 3 it follows that assisting PINC leads to an increase in microhardness by more than 3 times in comparison with the initial sample and 2 times in comparison with titanium nitride coating.


a)   b)
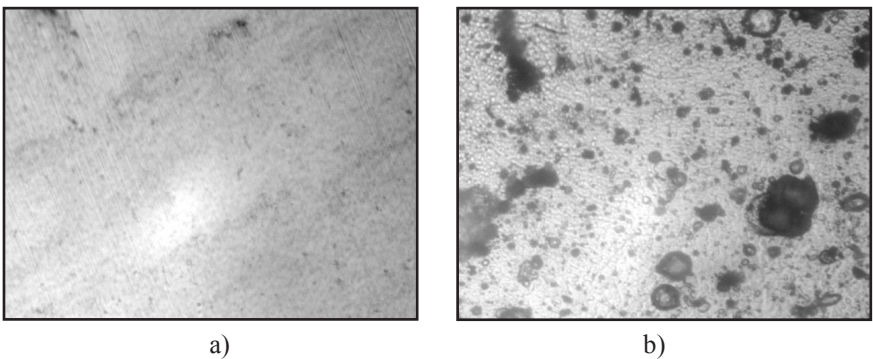
Figure 5 - Surface 20Cr13 without coating (a) and with titanium nitride coating (b)

Table 3 - *Microhardness μ of a turbine blade sample without coating and with titanium nitride coating applied within 2 hours without PINC and with PINC assistance for 20 minutes at a load of HV 0.05 = 0.49N*

μ, HV	271,5	263,1	258,7	254,2	269,4	258,4	263,1	**The average**	**263,3**
μ, HV	406,3	398,9	401,0	345,1	420,1	408,9	429,2	**The average**	**403,3**
μ, HV	986,3	823,9	857,0	883,1	996,2	883,6	854,1	**The average**	**909,3**

Application of the FeCrNiTiZrCu magnetron coating according to Method 4 [8] for 4 hours on blades made of steel 20Cr13 with two targets with double-row tablets using a dual magnetron power supply with PINC switched on, shown in Fig. 6.
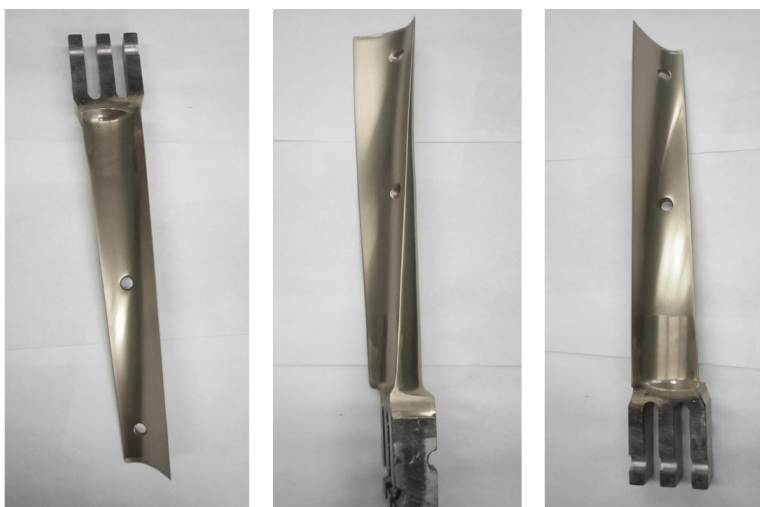
Figure 6 - *Turbine blades coated with FeCrNiTiZrCu*

The microhardness of the FeCrNiTiZrCu coating is 740 HV, which is slightly inferior to titanium nitride coatings assisted by PINK (910 HV). But the coefficient of friction is 2 times lower than that of titanium nitride coatings. Since spraying with pure titanium is more expensive than FeCrNiTiZrCu coatings, a contract for FeCrNiTiZrCu coatings of turbine blades was signed at the Karaganda Turbomechanical Plant. The negotiated value of the blades was 10% of the value of the blades themselves.

Details of rolling stock locomotives. The restoration of worn-out parts in compliance with the mating conditions is carried out by changing the dimensions - by the method of repair dimensions, or by restoring not only the mating conditions, but also the dimensions [9]. The following parts are provided (fig. 7).

a)   b)

Figure 7 - Connecting pin of the locomotive drive disk (a) and its drawing (b)

Coating FeCrNiTiZrCu for 1 hour on the samples of the connecting pin with two targets with double-row tablets using a dual magnetron power supply with different parameters (Fig. 8).

a)   b)

Figure 8 - Installation with two magnetrons (a) and parts of locomotives coated with FeCrNiTiZrCu (b)

The microhardness of the FeCrNiTiZrCu coating is not inferior to high-entropy equiatomic alloys and is much higher (740 HV) than that of stainless steels, which are used to manufacture parts in Fig. 8: stainless steel - 316 - 189 HV: stainless steel - 17-4 PH - 410 HV.

Such technology is being implemented by such American companies as Ktech, ASB Industries, Army Research Lab, Inovati, as well as firms from other countries: Windsor University (Canada), Helmut Schmidt University (Germany), CSIRO (Australia), Ecole de Mines (France), Tampere University of Technology (Finland).

Enterprises have shown economic interest in technology:

- in the Karaganda region - these are RGTO plants for the repair of mining and transport equipment, Mining Machines, Energozavod, Karaganda Turbomechanical Plant, Tsentrenergomekhanizatsiya, Foundry and Mechanical Plant and others;

- in Pavlodar region - "Pavlodar plant of metal structures - Imstalkon", "Interstal PV" and others;

- in the West Kazakhstan region - "Ural Mechanical Plant", "Ural Auto Repair Plant", "Uralskagroremmash", "Dormash", etc .;

- in the East Kazakhstan region - Ust-Kamenogorsk lead-zinc, Leninogorsk polymetallic, Zyryanovsk lead, East Kazakhstan copper-chemical, Irtysh polymetallic plants.

Conclusion

As a result, the following conclusions can be drawn:

- a pilot production site has been created and is operating on the basis of vacuum systems of the serial installation NNV 6.6-I1, which contains a gas plasma generator with a hot cathode and two electric arc evaporators in the working chamber. A preparatory area and a coating quality control area have been created;

- beaters with CrNiTiZrCu coating showed: microhardness increases by about 1.6 times; wear resistance increases 7.5 times; the coefficient of friction is reduced by almost 20 times! The microhardness of the coating on FeCrNiTiZrCu turbine blades is 740 HV, which is inferior to titanium nitride coatings assisted by PINK (910 HV). But the coefficient of friction is 2 times lower than that of titanium nitride coatings. The microhardness of the FeCrNiTiZrCu coating is not inferior to high-entropy equiatomic alloys and is much higher (740 HV) than that of stainless steels that are used to manufacture parts of mine equipment stainless steel - 316 - 189 HV: stainless steel - 17-4 PH - 410 HV.

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«Fateevskaya»矿泉水（B, Br, I, Mg）组成中的微量元素特征。 它们对人体的意义。

CHARACTERISTICS OF TRACE ELEMENTS IN THE COMPOSITION OF «FATEEVSKAYA» MINERAL WATER (B, BR, I, MG). THEIR SIGNIFICANCE FOR THE HUMAN BODY

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抽象。注意到一个人的"基本画像"与其健康状况之间的相互关系。在这方面，矿物质在重要过程中的重要性正变得越来越紧迫。在整个生命中，人体中微量元素的不断循环是从外部来的。由于微量元素的失衡，会发生微量元素的缺乏（RAMS A.P. Avtsyn的学者，1991年）。

越来越多的研究证实了溴和硼在代谢过程中的重要作用（有条件的基本元素）。碘和镁等元素对生命（必需的）起着特殊的作用。

因此，研究专家对营养泉水，化学家，生物化学家的兴趣引起了对矿泉的搜索和研究的兴趣。

含有B, Br, I, Mg和其他元素的矿泉水" Fateevskaya"（2015年6月15日的水疗学结论，编号IC-56 FSBI俄罗斯医学康复和Balneology科学中心）已确立其自身为Balneotherapy的有效手段。

关键字：balneotherapy，矿泉水，大量元素，微量元素。

Abstract. *The interrelation of the "elemental portrait" of a person and the state of his health is noted. In this regard, the topic of the importance of mineral substances in vital processes is becoming more and more urgent. Throughout life, there is a continuous circulation of trace elements in the human body, coming from outside. With an imbalance of microelements, microelementosis occurs (Academician of the RAMS A.P. Avtsyn, 1991).*

More and more studies confirm the important role of bromine and boron in metabolic processes (conditionally essential elements). Elements such as iodine and magnesium have an exceptional role for life (essential).

That is why the search and study of mineral springs is of interest to research specialists: nutritionists, chemists, biochemists.

Mineral water "Fateevskaya" (Balneological conclusion of 15.06.2015 No. IC-56 FSBI Russian Scientific Center for Medical Rehabilitation and Balneology), containing B, Br, I, Mg and other elements, has established itself as an effective means of balneotherapy.

Keywords: *balneotherapy, mineral water, macroelements, microelements.*

The solution of urgent problems to establish the role of macro- and microelements in ensuring human and animal health is attracting more and more attention of specialists [1]. According to the literature, only 3% of the world's population do not have disorders of mineral metabolism, which are the root cause or indicator of approximately 95% of all known diseases [2].

The beginning of the study of elements in the human body was noted in the second half of the XIX century [3]. Currently, there has been a progressive growth in the development of modern bioelementology [4].

Trace elements in many enzymes and proteins play an important role in reparative processes [5], are the most important catalysts for various biochemical processes, correct aging processes [6,7,8], regulate humoral and reflex mechanisms that have an effect on the blood and nervous system, prevent the growth of malignant neoplasms Z.K. [9]

The main migration and redistribution of chemical elements in the biosphere occurs due to their transfer by the aquatic environment. [10] Underground mineral springs accumulate many macro- and microelements [11].

Russia is the largest world power with a unique natural resource potential of groundwater. It could provide the industrial production of iodine, bromine, lithium, cesium, boron and strontium compounds, sodium, calcium and magnesium salts on a scale that fully satisfies the needs of the branches of the national economy that need them [12, 13].

The study of the chemical composition of mineral waters laid the foundation for scientific balneology, the development of which has become an independent branch of theoretical and applied medicine [14].

Currently, there are several balneological groups of mineral waters: waters, the action of which is determined by the ionic composition and mineralization; carbonic waters; hydrogen sulfide waters; ferrous waters; bromine, iodine and iodine-bromine waters; siliceous thermal waters; arsenic water; radon (radioactive) waters; boron waters; waters enriched with organic matter [15].

The therapeutic activity of most mineral waters is associated with the presence of organic and inorganic salts of Fe, As, Co, I, Zn, Mn, Cu, B, and others [16]. The high prospects of the industrial development of brines have been established (technological schemes for their processing with the production of lithium, magnesium, bromine products and iodine have been developed, the fundamental possibilities of obtaining boron, rubidium, cesium and strontium have been evaluated) [17]. Sodium chloride mineral waters, enriched with bromine and iodine, characterized by different mineralization and temperature, are widespread in our country and abroad and are actively used for balneological purposes [18].

The importance of the elements is very great in the balneological assessment of mineral waters and in determining their potential as an effective remedy [19].

On the territory of the Kirov region, more than a dozen mineral water deposits have been explored and are used. Mineral waters are used for medicinal purposes by various cosmetology, medical and spa facilities and are supplied to factories for bottling. The largest part of the deposits is located in the Nizhne-Ivkinskaya resort area (Nizhne-Ivkino settlement, Kumensky district). The known mineral sodium chloride water of the Bolshedubrovsky mineral springs with an admixture of sulphate and carbonate salts of calcium, magnesium, potassium (the village of Bolshaya Dubrova, Uninsky district).

According to the protocol (№28 of September 26, 2007) of the meeting of the territorial commission of Kirov, at the Fateevskoye deposit (Fateevo village, Kirovo-Chepetskiy district) of mineral medicinal waters, an assessment of the reserves of mineral waters was carried out. The approved operational reserves of category C1 are 17.2 m3/day. A water point was registered - well №6, TU 9185-001-52355209-04 "Highly mineralized mineral water (brine)" Fateevsky "(copyright holder: LLC "Industrial and commercial enterprise "FROL", Kirov). In terms of chemical composition, it is a brine (M 55.0-60.0 g/dm3) of sodium chloride (magnesium-sodium) (Cl>90, Na++K+60-80, Mg2+15-25 mg-eq. %), with a slightly alkaline reaction of the medium (pH 7.6-7.9) containing in conditioned amounts of bromine (Br-140-160 mg/dm3), iodine (I 5-9 mg/dm3) and boron (H3BO3 mg/dm3). By the name of the group - sodium chloride, iodine-bromine, boric, brine. Balneological conclusion of 15.06.2015 № IC-56 FSBI Russian Scientific Center for Medical Rehabilitation and Balneology.

Chemical composition formula:

C1 94

M 60,5 (Na + K) 67 Mg 20 Ca 13   (A1)

$$\text{Sp: Br - -151,0 mg/dm3}$$
$$\text{J - - 5,0 mg/dm}$$
$$\text{H3BO3 - 87,0 mg/dm}$$

Iron in charge:
Σ Fe - 1,75 mg/dm

BORON - conditionally essential trace element.

More than half of the total amount of boron is found in the skeleton, about 10% - in soft tissues (nervous tissue, adipose tissue, parenchymal organs). Boron plays a role in metabolism, affects the activity of certain enzymes. An insufficient content of boron in the body of elderly women causes a deterioration in the state of mineral metabolism and bone tissue (osteoprosis) [20]. Many researchers (Kovalsky V.V., Ermakov V.V., 1974; Peive, 1974) argue that boron has a positive effect on the processes of nitrogen fixation by bacteria from the genus Azotobacter. The positive effect of boron on the dehydrogenase, catalase and other types of activity of many rhizosphere bacteria has been established. Boron content in cereals is 0.1 mg/kg, and in grasses it increases to 38 mg/kg; in vegetables, its content is 0.9-5.8 mg/kg of dry matter (Suslikov, 2000).

Also known is bis(glycero)boric acid HB $(C_3H_6O_3)_2$, a 10% solution in glycerol exhibits more pronounced acidic properties and has an antiseptic effect [21, 22]. In this regard, boron and its compounds are widely used in modern medicine [23]. A number of works are devoted to the study of the antibacterial and antifungal activity (bacteria, microscopic parasitic fungi and saprophytic forms of bacteria) of low molecular weight boron compounds [24]. The study of the effect of boric acid on the pathogenic yeast Candida sp showed that the fungistatic effect was observed when the concentration of borate in the nutrient medium was less than 0.02 M. The concentration of 0.64 M already had a pronounced fungicidal effect. This proves that boron ions affect biological oxidation-reduction processes in cellular systems [23].

The antibacterial effect of boron is associated with the fact that it suppresses the self-organization of bacteria and, thereby, prevents the formation of a bacterial film [25]. Among other possible mechanisms of the antibacterial action of boron, a violation of protein synthesis can be noted; dysfunction of mitochondria; violation of bacterial cell division; interaction with enzymes (stimulation, stabilization, inhibition); deterioration of the functions and integrity of membranes and membrane potential [26].

BROMINE is also a conditionally essential trace element.

Bromine is one of the most important participants in the formation of the food chain: atmosphere - soil - _natural waters_ - plants - animals - humans [27]

Among the chemical elements that most often lead to an increased risk to human health, bromine is isolated [28]. The question of its essence has not been clearly established for a long time, primarily due to insufficient knowledge of its biological role [29] In 2014, the results of a study by Vanderbilt University (USA)

showed that "without bromine there is no life": without bromine, type IV collagen molecules that play an important role in maintaining the integrity of the epithelial and endothelial cell membranes, they cannot bind to each other properly for the formation of a structural protein of the connective tissue, which can lead to a violation of its development, ultimately to the death of the organism [30] In addition, bromine is a permanent compound part of normal gastric juice [31].

This trace element is necessary in the human body to perform the following functions: to activate enzymes: pepsin, amylase and lipase; to normalize the functions of the thyroid gland (helps in the prevention of endemic goiter); for the regulation of the relationship between the processes of excitation and inhibition in the central nervous system [32].

The main source of bromine is seafood. Most of the element found on planet Earth is concentrated in oceanic waters. A small amount of the element is found in sea fish, as well as in table salt. The mineral is also concentrated in the water of salt lakes and in underground springs, from which medicinal bromine waters are obtained [33].

With its lack, a complex of pathological processes develops, leading to a violation of the homeostatic functions of the body. For hypomicroelementosis of bromine, herbal remedies can be used, including food species, pharmacological preparations, and bromine-containing mineral waters. With an increased intake of bromine in the body, a typical toxicogenic symptom complex of disorders develops [34].

IODINE – is a vital trace element. Iodine is involved in the regulation of the rate of biochemical reactions in the body, in the regulation of various types of metabolism and vitamins, in the differentiation of tissues, in the processes of growth and development. The main reason for the decrease in the iodine content in the body is the insufficient level of this element in food and water. This, in turn, leads to the development of iodine deficiency states and diseases (endemic goiter, hypothyroidism, cretinism, etc.). The manifestations of iodine deficiency in the body are numerous and varied: an increase in the production and release of thyroid hormones, the formation of goiter, the development of iodine deficiency diseases (hypothyroidism, cretinism), congenital malformations, increased infant mortality [35] in conditions of iodine deficiency, decrease by an average of 10-15 % [36]. Even a moderate deficiency leads to reproductive system disorders [37].

MAGNESIUM is a vital structural element [38], regulating the activity of hundreds of enzymes, covers ≈ 80% of known metabolic functions [39]. Against the background of a low magnesium content, the aging process of the cell is accelerated, and vice versa: maintaining it at the physiological level can slow down the aging process [40]. Somatic magnesium deficiency in the body is a risk factor for atherosclerosis, hypertension [41], leads to aggravation of the manifestations of

climacteric syndrome and osteoporosis (about 53% of magnesium is concentrated in bone tissue, dentin and tooth enamel [42], diabetes mellitus [43]).

According to the authors, the content of magnesium in people of mature age is at the lower limit of the average Russian indicators and a tendency to decrease with increasing age is noted [44]. As a result of research, in recent years, the level of trace elements, including magnesium, is significantly reduced in plant food by 80–90% [45].

Consequently, the growth of a colossal deficiency of magnesium and other elements and the importance of studying the sources and methods of their entry into the human body are quite predictable. That is the reason for the ever increasing popularity of balneology.

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甲醇中苯乙烯–环氧–氯化铜（II）–三元醇三元体系的分子氧氧化
MOLECULAR OXYGEN OXIDATION OF THE STYRENE EPOXIDE-COPPER(II) CHLORIDE-IONOL TERNARY SYSTEM IN METHANOL

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抽象。 研究了苯乙烯–环氧–$CuCl_2$–紫罗兰体系在甲醇溶液中对氧的吸收。 以试剂浓度表示的氧化速率表达以及有效氧化速率常数的阿累尼乌斯依赖性形式表明了其复杂的机理。 氧气吸收率与紫罗兰醇浓度成正比。 关于环氧化物和催化剂氯化铜的反应顺序分别是分数，分别是0.4和0.5。 紫罗兰醇，环氧化物和氧吸收的消耗比率为1：2：5。基于消耗的环氧化物，氧化过程中自由基颗粒的产率达到~40%（V_{O_2} / V_{SE}）≈0.4。 首次表明，O_2的吸收是含有不同结构环氧化物的类似三元体系的特征。
关键词: 氧化分子氧环氧化物紫罗兰醇催化氯化铜甲醇自由基

Abstract. *The absorption of oxygen by the styrene epoxy - $CuCl_2$ - ionol system in methanol solution has been studied. The expression of the rate of oxidation in terms of the concentration of reagents and the form of the Arrhenius dependence of the effective rate constant of oxidation indicate its complex mechanism. The O_2 uptake rate is directly proportional to the ionol concentration. The reaction orders with respect to epoxide and catalyst, copper chloride, are fractional, 0.4 and 0.5, respectively. The rates of consumption of ionol, epoxide and oxygen absorption are in a ratio of 1: 2: 5. Based on the consumed epoxide, the yield of free-radical particles during oxidation reaches ~ 40% (V_{O_2}/V_{SE}) ≈ 0.4. It was shown for the first time that the absorption of O_2 is characteristic of analogous ternary systems containing epoxides of a different structure.*

Keywords: *Oxidation, molecular oxygen, epoxides, ionol, catalysis, copper chloride, methanol, free radicals.*

The widespread use of epoxy compounds in the world economic system is

based on the well-studied ability of epoxides to transform by heterolytic reactions. Accordingly, the vast majority of chemical research in world science is devoted to the study of the mechanism of heterolytic reactions of oxirane compounds. The last 25 years of studying the chemistry of epoxides have yielded, however, a number of results that are quite consistent with the reality for epoxides of variability of transformations of the heterolysis - homolysis type, i.e. competition of hetero- and homolytic reactions for these labile compounds. Examples of this kind: acid-catalytic consumption of styrene epoxide (SE) in the presence of p-toluenesulfonic acid (TSA) and perchloric acid is accompanied by oxygen absorption, i.e. the formation of intermediate particles of the radical type that react with oxygen [1, 2]. Oxidation is accompanied by the accumulation of benzaldehyde, a product of the degradation of the oxirane ring of the epoxide [3]. Recently, the nature of radical particles in this kind of oxidation has been established: these are phenylmethylene carbenes [4], which are capable of attaching oxygen and, in its absence, destroying hydroperoxides [5]. Another example: the reaction of styrene epoxide with α-naphthol at high temperature (140ºC) in the presence of TSA gives products that correspond to the classic heterolytic interaction of nucleophile (α-naphthol) with epoxide [6]. However, the study of the ternary systems TrS (SE – TSA – hydroquinone) and TrS (SE – CuCl$_2$ – α-naphthol) at a temperature ~ 70 ºC lower revealed an alternative to heterolysis route of oxidation of these systems with oxygen [7, 8]. The ratio of the rates of O$_2$ uptake and epoxide consumption in the system with hydroquinone $V_{O_2}/V_{SE} \approx 0.24$, i.e. the yield of free-radical particles per consumed epoxy was> 20%.

Below are the results of studying the catalytic reaction of O$_2$ absorption by the ternary system TrS (styrene epoxy – CuCl$_2$ – ionol); ionol (IOL), widely used in science and practice, is an inhibitor of radical oxidation processes. The oxidation rate (V) was measured volumetric from the O$_2$ uptake. Consumption rates of SE and IOL were determined from HPLC analysis.

The dependences of the initial oxidation rates on [CuCl$_2$] and [SE] are shown in Figure 1. They were used to calculate the values of private orders n, fractional values, $n_{Cu} = 0.5$, $n_{SE} = 0.4$, respectively. The oxidation rate is proportional to the [IOL] value in the solution ($n_{IOL} = 1$) and the O$_2$ content in the gas mixture, see Figure 2. $V = k$ [SE]$^{0.4}$ [CuCl$_2$]$^{0.5}$ [IOL]^1 (at 100% oxygen in the gas phase). Based on the experimental data at different temperatures (317 - 330 K), the effective values of the activation energy E_a and rate constants in the Arrhenius form were calculated: E_a = 50.2 kJ/mol, k = 4.8 × 10^6 exp (- 50.2/RT).

Search experiments on the oxidation of several ternary systems (epoxy – CuCl$_2$ – IOL) with different epoxides showed that oxygen absorption is characteristic not only of one TrS based on styrene epoxide: this position is confirmed by the data in Fig. 3. Absorption curve *1* Fig. 3 refers to the new ternary system TrS (BGE - CuCl$_2$ - IOL), where BGE is butyl glycidyl ether.
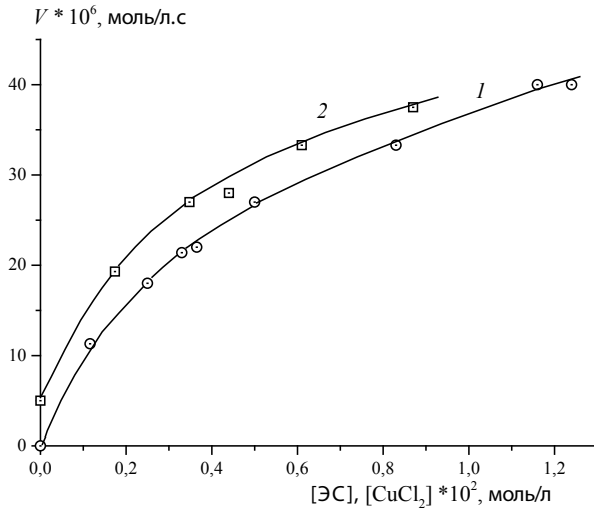
Fig. 1. *(1, 2) - dependences of the rate of oxidation of the ternary system (SE – CuCl₂ – IOL): from [CuCl₂ · 2H₂O], [SE] = 0.35 mol/l (1); from [SE], [CuCl₂ · 2H₂O] = 5 × 10⁻³ mol/l (2). [IOL] = 0.0164 mol/L, CH₃OH, 323 K.*
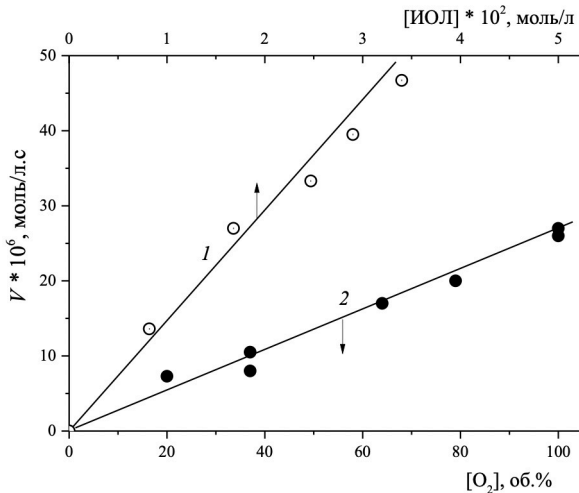
Fig. 2. *(1, 2) - dependences of the oxidation rate of the ternary system (SE – CuCl₂ – IOL) on the concentration of ionol (1) and on the percentage of oxygen in the oxidizing gas at [IOL] = 0.0164 mol / L (2). [SE] = 0.35, [CuCl₂ · 2H₂O] = 5 × 10⁻³ mol/l, CH₃OH, 323 K.*
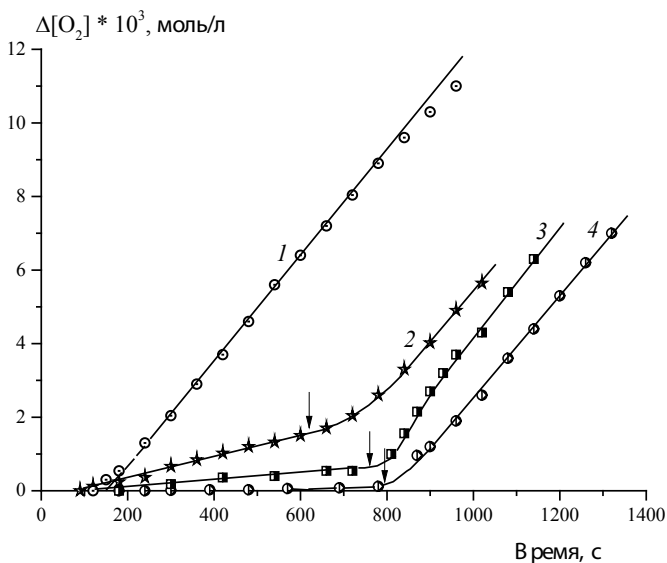
Fig. 3. Kinetic curves of oxygen absorption (1 - 4): ternary system with 0.28 mol/l BGE, 0.005 mol/l CuCl$_2$, and 0.0136 mol/l IOL (1); binary systems CuCl$_2$ – IOL (2), BGE – CuCl$_2$ (3), BGE – IOL (4) before and after the introduction (marked with an arrow) of the missing component of the ternary system of experiment 1. CH$_3$OH, 323 K.

Kinks of kinetic curves *2, 3, 4* Fig. 3, i.e. acceleration of oxidation is associated with the introduction of the missing third component TrS (BGE – CuCl$_2$ – IOL) into binary systems, see the caption to Fig. 3. The discovery of new ternary systems based on epoxides other than styrene epoxy significantly increases the number of objects and the potential for research in this area.

Figure 4 illustrates the effect of the introduction of the missing component of the studied TrS into the initial binary systems, solutions of pairs of components SE - IOL (*1*), SE - CuCl$_2$ (*2*), CuCl$_2$ - IOL (*3*). It follows from these data that SE, CuCl$_2$, and IOL do indeed form TrS, in which epoxy and ionol are consumed and O$_2$ is absorbed in this case. For these three processes, the inequality $V_{TrS} \gg \Sigma V_{DC}$ is valid; V_{TrS} and V_{DS} correspond to the rates of SE, IOL consumption and O$_2$ uptake. The value of the ratio of homolytic and nonradical routes of SE transformation (V_{O_2}/V_{SE}) was estimated. The initial velocity V_{SE} was calculated as the average value of the slopes of the initial sections of the SE consumption curves *1, 2, 3* in Fig. 4.
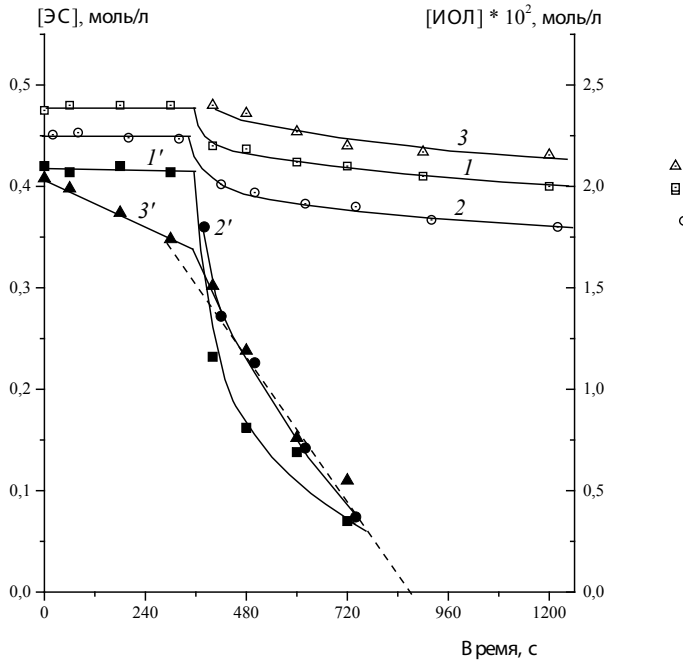
Fig. 4. *Curves of changes in [SE] (light points) and ionol (dark points) before and after the introduction of the third component at 6 minutes into the corresponding binary systems: 1, 1' - CuCl$_2$ in DS (SE – IOL), 2, 2' - ionol in DS (SE – CuCl$_2$), 3, 3' - epoxide in DS (CuCl$_2$ – IOL). [SE] = 0.47, [CuCl$_2$] = 0.011, [IOL] = 0.021 mol/l. Oxygen, CH$_3$OH, 323 K.*

In the time interval the seventh - tenth minutes, i.e. for the first three minutes in experiments *1, 2, 3* fig. 4, on average ~ 0.025 mol/l SE is consumed, hence $V_{SE} \approx$ 1.4 × 10^{-4} mol/l·s. Calculated from the concentration dependence $V_{O_2} = k$ [SE]$^{0.4}$ [CuCl$_2$]$^{0.5}$ [IOL]^1 ($k = 0.034$) oxidation rate $V_{O_2} = 5.5 \times 10^{-5}$ mol/l·s, and the ratio $V_{O_2}/V_{SE} \approx 0.39$, i.e. the contribution of the radical process to the gross consumption of styrene epoxy is about 40%. This is the highest yield of radicals in the studied systems based on the catalyzed conversion of SE, so far the highest yield (~ 24%) has been recorded in the ternary system (SE – TSA – hydroquinone) [7]; the detection of systems with a radical yield> 50% is promising from the point of view of the creation of new radical initiators on an epoxy basis. Calculating the slope of the dotted line in Fig. 4 the rate of consumption of ionol $V_{IOL} = 2.6 \times 10^{-5}$, using the values calculated above $V_{O_2} = 5.5 \times 10^{-5}$ and $V_{SE} = 1.4 \times 10^{-4}$ mol/l·s, we find $V_{O_2}/V_{IOL} = 2.1$, $V_{SE}/V_{IOL} = 5.4$; the consumption of one inhibitor molecule is

accompanied by the absorption of two O_2 molecules and the consumption of five SE molecules.

The assumption of the first approximation, the hypothesis of the essence of the complex mechanism of TrS oxidation (epoxy - $CuCl_2$ - phenol) consists in the assumption of the possibility of an electron transfer reaction in the phenol - Cu (II) - epoxide complex upon homolytic rupture of weak O - H and C - O bonds of ionol and epoxide, respectively :

$$Ph'- OH...Cu^{2+}...O\overset{Ph}{\diagup} \longrightarrow Ph'O^{\cdot} + H^+ + \overline{O}CH_2 - \overset{\cdot}{C}H - Ph \overset{O_2}{\longrightarrow} HOCH_2 - \overset{OO^{\cdot}}{\underset{|}{C}}HPh (RO_2^{\cdot})$$

death
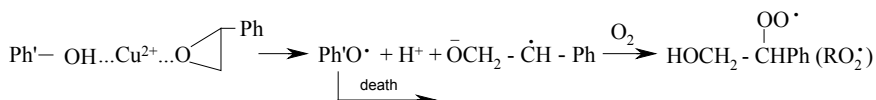
The future will show the degree of reality of this hypothesis.

The work was carried out on the topic of the State Assignment, State Registration № АААА – А19–119071890015–6.

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新型生物电催化剂：大肠埃希氏菌的"粗"蛋白提取物
NEW TYPE OF BIOELECTROCATALYST: "CRUDE" PROTEIN EXTRACT OF *ESCHERICHIA COLI*

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抽象。 已经证明了一种新型的生物电催化剂，即"粗"蛋白提取物。 结果表明，多种因素影响这种提取物的生物电催化活性：培养物的生长时间；培养时间。氧化还原介体系统的性质； pH，温度，离子强度，缓冲液系统的性质； 提取物，底物和介质的浓度。 已经证明透析后，蛋白质提取物的生物电催化活性消失，但是当引入NAD辅因子时，活性恢复。
关键词：生物燃料电池介质生物电催化酶动力学粗蛋白提取物

Abstract. *A new type of bioelectrocatalyst, a "crude" protein extract, has been demonstrated. It is shown that various factors affect the bioelectrocatalytic activity of such an extract: the time of culture growth; the nature of the redox mediator system; pH, temperature, ionic strength, nature of the buffer system; concentration of extract, substrate and mediator. It has been demonstrated that after dialysis, the bioelectrocatalytic activity of the protein extract disappears, but when the NAD cofactor is introduced, the activity returns.*

Keywords: *biological fuel cells, mediator bioelectrocatalysis, enzymatic kinetics, "crude" protein extract*

The study of bioelectrocatalytic processes and the development of new bioelectrocatalysts is one of the urgent tasks of modern electrochemistry. Such studies are at the intersection of different sciences: biochemistry, electrochemistry, kinetics and catalysis. The increased interest in biological catalysts is caused, first of all, by their high catalytic ability in comparison with metal catalysts. Due to their high selectivity, as well as their indifference to CO, these catalysts find their application in sensor devices and fuel cells. In the latter case, biocatalysts replace Pt in MEBs.

Among the known variety of biological catalysts, three types can be distinguished: pure enzymes, microorganisms, and biomimetics [1,2,3]. Each of these types of biocatalysts has a number of advantages and disadvantages. Enzymatic fuel cells generate higher current densities than microbial fuel cells, but obtaining a pure enzyme is costly and complex multi-step process. The production of microbial catalysts is simpler in comparison with enzymatic ones, but the service life and stability of the microbial fuel cell is limited by the life span of the microbial cell, and the accumulated waste products of microorganisms in the electrolyte can have a negative effect on the operation of the device. The design of biomimetic catalysts is one of the promising trends in the development of bioelectrocatalysis. Biomimetics are synthetic substances that simulate biological systems at the molecular level. This direction is now actively developing, however, the creation of such catalysts is also a laborious and costly process.

Earlier we reported about 4 type of bioelectrocatalyst –"crude" protein extract [4,5,6,7]. The method of obtaining "crude" extract by disintegrating bacterial biomasses is simpler and more economical in comparison with pure enzymes. From a scientific point of view, the study of the biocatalytic properties of "crude" extracts is very interesting, since the disintegrated biomass contains a cascade of enzymes involved in the metabolism of microorganisms, and coenzymes necessary for oxidative/reductive transformation. This set of bioactive substances allows simulating the processes occurring during the operation of a "natural" fuel cell in an artificial environment. *Escherichia coli* culture was chosen as a model system for the development of this technology.

A method for obtaining a "crude" protein extract was developed and the factors influencing the biocatalytic activity of the extracts were studied. Thus, it was found that with an increase in the growth time of the culture, the amount of protein in the biomass increases and passes through a maximum. At the same time, different enzymes are produced at different periods of bacterial growth, thus, it was shown that both dehydrogenase and electrochemical activities for a culture disintegrated at certain growth phases differ. It was found that the activity of enzymes changes during the growth of the culture, and the most noticeable changes are observed for glucose dehydrogenase activity. Throughout the entire period of bacterial growth, enzymes that use potassium citrate and malate as substrates are most active. This reflects the activity of the enzymes of the tricarboxylic acid cycle, aconitase and isocitrate dehydrogenase in the case of potassium citrate and malate dehydrogenase in the case of potassium malate. By the end of the stationary growth phase, the activity of these enzymes decreases markedly. Lactate dehydrogenase and alcohol dehydrogenase activity is at a low level during the entire observation period [4].

The electrochemical activity of the obtained extract was tested in the presence of various redox mediators, which are usually used for pure enzymes. For a number of them, the effect of irreversible interaction of the reduced form of the mediator with a protein extract (methylene blue) or an oxidizable substrate (benzoquinone) was found, which leads to inhibition of the measured current responses. The result of this study was the selection of the optimal redox mediator system (potassium ferricyanide). This mediator has the necessary characteristics for effective bioelectrocatalysis: reversible redox transition; is inert with respect to the substrate; during the reaction, there are no by-products formed during the interaction of the mediator with protein molecules; is inert with respect to oxygen; the generated current response in the "mediator + extract + substrate" system is higher than when using other investigated mediators [5].

Information was obtained on the effect of various factors (pH, temperature, ionic strength, nature of the buffer system, extract content) on the biochemical and electrocatalytic activity of the studied extracts, some of which (the nature of the buffer and its concentration, the optimal protein concentration) are usually not taken into account in literature in the study of electrochemical activity. Buffer systems were selected, when used as an electrolyte, the highest values of current responses are achieved (potassium phosphate buffer and TRIS buffer system). The optimal values of the ionic strength for the used buffer systems were chosen: 0.1 M TRIS and 0.5 M potassium phosphate buffer. The effect of temperature under the selected conditions on the biocatalytic activity of crude protein extracts was studied. The highest electrocatalytic activity of "crude" extracts is shown at 450C, after which a region of inactivation of enzyme systems sets in. The activation energy for the process under study was 35 kJ/mol [5].

The influence of the concentrations of reagents (extract, mediator, substrate) on the efficiency of the process of glucose oxidation by protein extracts was studied and their optimal values were selected. It was found that in the case of an increase in the concentration of the substrate, the bioelectrocatalytic activity decreases due to the phenomenon of substrate inhibition [7].

"Crude" cell extract contains many different components of protein and non-protein nature. Some of these components can interfere with the efficient operation of the biofuel cell, for example, by clogging the gas diffusion layer, or due to the likely presence of peptidases, reducing the shelf life of the bacterial extract. To eliminate these problems, proteins are purified by different methods. One such purification method is dialysis, which separates proteins by molecular weight. It has been shown that after dialysis, dehydrogenase activity is completely absent in the crude extracts. However, the introduction of the cofactor NAD leads to the return of enzymatic activity. This suggests that the enzyme systems presented in the crude extract are NAD - dependent. In this case, the concentration of the cofactor directly affects the rate of the bioelectrocatalytic reaction [6].

Taking into account the optimal conditions in a 3-electrode electrochemical liquid cell, 320 μA/cm^2 was obtained during mediator oxidation of glucose by protein extracts from *E. Coli* (Fig. 1).
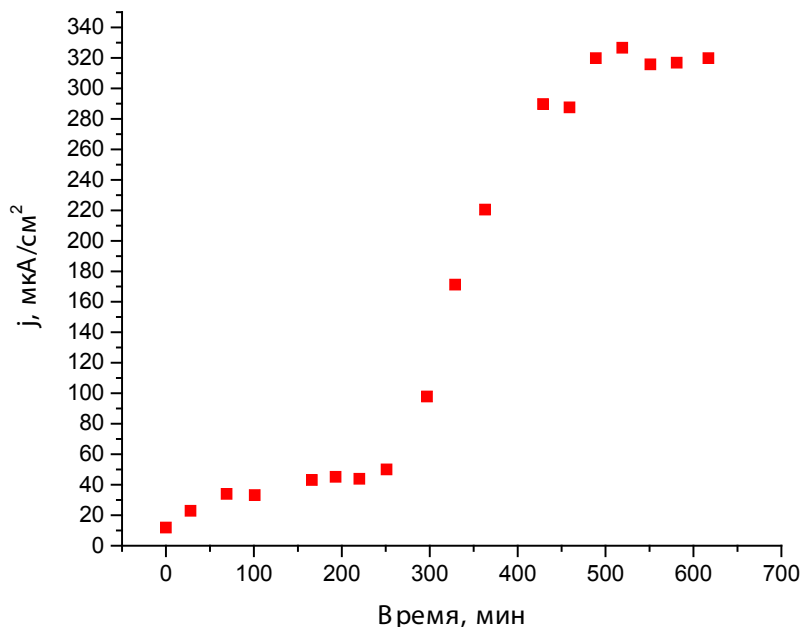
Figure: 1. *Current responses obtained in a 3-electrode liquid cell, taking into account the optimal conditions for the operation of the bioelectrocatalyst [6].*

In general, the results obtained on extracts of E. coli culture show the fundamental possibility and prospects of using economical crude protein extracts as oxidizing agents for organic fuel.

This work was supported by the scholarship program of the President of the Russian Federation № SP-2619.2018.

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喹啉醚对弹性体硫化方向的发展
DEVELOPMENT OF THE DIRECTION OF VULCANIZATION OF ELASTOMERS WITH QUINOL ETHERS

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抽象。 本文讨论了用喹诺酯对弹性体进行硫化的合成方法和发展方向。
关键字：喹诺酸酯，合成，弹性体硫化反应。
Abstract. The article discusses the synthesis and development of the direction of vulcanization of elastomers with quinol esters.
Keywords: Quinol esters, synthesis, elastomer vulcanization reactions.

An important milestone in the development of Soviet systems of cold, or low-temperature vulcanization was the discovery of a new class of quinol esters of *p*-quinone dioxime.

As noted in [1-4], the heterogeneous redox system *p*-quinone dioxime (PQDO) + MnO_2 was successfully replaced by quinol ether. The idea of using quinol esters was recognized in the industry and was then successfully applied [1-5]. Fig. 1 shows a model of the RSM-52 rocket installed in the USSR on board nuclear submarine missile carriers in the Northern Fleet [1, 4].

Fig. 1. *Model of the RSM-52 intercontinental solid-fuel rocket at the entrance to FRPC "Altai".*

An interesting story of the discovery of quinol esters should be noted. The vulcanizing ability of quinol ether was first discovered in the early 1970s by V.V. Zorik at SPA "Altai", Biysk [6]. Valentina Vasilievna added a multiple excess of a heterogeneous vulcanizing system of 2,4,6-tri-*tert*-butylphenol (P-23) and PQDO with an oxidizing agent to the composition under study, after the mixture was heat-treated, she found yellow crystals of EKh-1 on the surface of the vulcanizate, which further showed excellent vulcanizing ability, solubility in plasticizer and rubber, unique physical and mechanical characteristics. Mueller was the first to carry out such a reaction [7, 8] by the interaction of the phenoxyl radical P-23* with PQDO in a solvent, however, his studies of the PQDO dehydrogenation reaction ended there.

The synthesis of quinol esters is carried out by condensation of *p*-benzoquinone dioxime derivatives with sterically hindered phenols in the presence of oxidizing agents - MnO_2 and etc. [9, 10] according to the scheme:
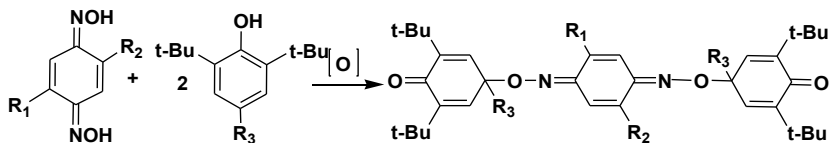
Studies of the kinetics of vulcanization of SKI-3 and SKEPT-40 (ENB) rubbers were carried out in [11] on a Monsanto-100S" rheometer, using a number of quinol esters as vulcanizing agents, see Table 1, at a concentration of 2.5%.
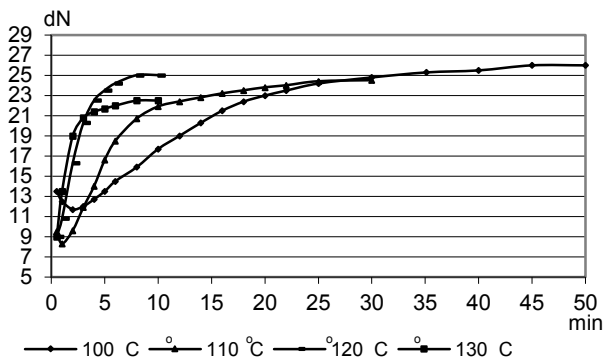
Fig. 2. *Kinetic curves of vulcanization of SKEPT-40 (ENB) rubber with EKh-1 ether*

This fact was associated with the absence of the effect of the solvent on the kinetics of the process and the shift of equilibrium during the dissociation of ether towards the formation and consumption of *p*-dinitrosoarenes, $k_1 \gg k_2$.
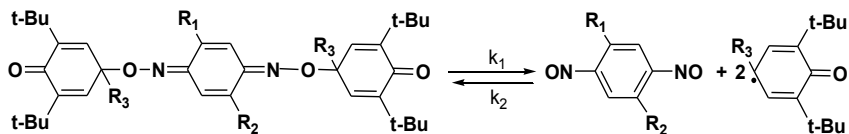
The effective cure rate constants were calculated using eq.1:

$$k = \frac{1}{\tau_{M90\%}} \cdot \ln \frac{M_{max} - M_{min}}{M_{max} - M_{90\%}}, \ s^{-1} \tag{1}$$

where: $\tau_{M90\%}$ – time to reach the optimum (90%) of vulcanization, s; M_{max}, M_{min}, $M_{90\%}$ – maximum and minimum torque values, as well as the current value of the torque at the optimum vulcanization (90% of the maximum), dN·m

The critical temperature T_{cr}, determined from eq. 2 from the found Arrhenius parameters (E, J, and logA), at which the rate constant of vulcanization was chosen as a value characterizing the reactivity of quinol ethers was $k=1\cdot10^{-6}$, s^{-1}.

$$T\,кр = \frac{E}{19{,}142 \cdot (6 + \lg A)} - 273{,}15, \ ^{o}C \tag{2}$$

The found activation characteristics and T_{cr} values are presented in Table 1.

Table 1.

Activation characteristics of the vulcanization reaction with quinol ethers

№, name	EKh, R_1, R_2, R_3	$T_{melt.,}$ °C	Rubber	$_\Delta$T, °C	E#± 2, kJ/mol	lgA± 0,2	Tcr ± 4, °C
EKh-1	H, H, t-Bu	168	SKI-3	100 - 130	90,0	10,1	18,4
			SKEPT-40 ENB	100 - 130	89,7	9,7	25,4
EKh-2	H, H, O-Me	165	SKI -3	100 - 130	83,7	9,4	11,8
EKh-10	Me, i-Pr, t-Bu	199	SKI -3	110 - 140	135,6	15,7	53,3
4	Me, i-Pr, Me	137	SKI -3	100 – 130	119,6	13,9	40,1
5	O-Et, H, t-Bu	168	SKI-3	100 - 120	114,6	13,5	34,3
6	O-Oct, H, tBu	130	SKI-3	100 – 130	109,6	12,6	34,3
7	Me, H, t-Bu	170	SKI-3	100 - 120	116,7	13,3	42,5
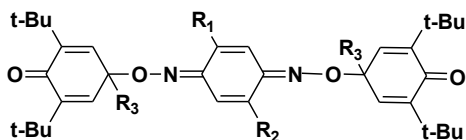
As you can see from the Table 1, the introduction of alkyl and alkoxy substituents into the quinone dioxime ring leads to a decrease in the reactivity (*Tcr*) of quinol esters, and EKh-10 has the lowest *Tcr* value among the studied compounds.

Differences in the activation parameters of vulcanization with esters EKh-1, EKh-2, etc., compared with EKh-10, should be sought in the different reactivity of dinitrosoarenes generated from the corresponding esters [12]. Earlier, in [13], it was suggested that the reactivity of nitrosoarenes in reactions of addition to alkenes decreases depending on the increase in the calculated values of the charge on the oxygen of the nitroso group (qO).

Calculations of the charges on the oxygen of the nitroso group with full optimization of the geometric parameters show lower values of the charges on the oxygen of the nitroso groups of monomeric p-dinitrosobenzene (DNB) and, as a consequence, its higher vulcanizing activity in comparison with 2-methyl-5-isopropyl-p-dinitrosobenzene (TDNB), where electron-donating alkyl groups have a deactivating effect on the nitroso groups of TDNB.

The difference in the charge values on the oxygen TDNB allows predicting the first act of its addition to the olefin by the nitroso group located at the methyl substituent with a charge qO = - 0.273. The second nitroso group, TDNB, is less active due to a slightly higher charge on oxygen and steric hindrance from the *iso*-propyl radical. These circumstances generally lead to a decrease in the reactivity of the EKh-10 ester in comparison with other quinol esters.

Shown in fig. 3 quantum-chemical calculation by the b3lyp 6-31G (d) (opt, freq) method of the monoester EKh-1 radical showed the delocalization of the unpaired electron along the quinoid ring and nitroso group:
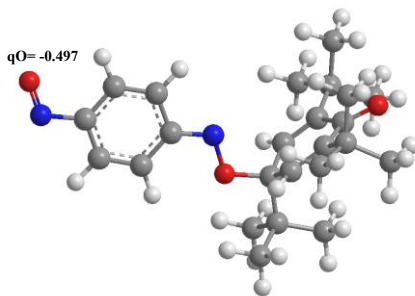
Fig. 3. *Calculated structure of the EKh-1 monoester radical*

A relatively high calculated value of the charge on oxygen of the nitroso group qO= - 0,4970, which, in accordance with the linear dependence lgk=11,3+49,7·qO found, determines the rate constant of the addition reaction (k) of the monoester radical to rubber low, with k=1,76·10^{-6}, s^{-1}, while monomeric DNB has a charge on the oxygen of nitroso groups qO= -0,264 and k=1,62·10^{-1}, s^{-1}, which is five orders

of magnitude higher. Thus, the hypothesis [14] about the addition of the EKh-1 monoester radical to rubber is also not confirmed.

It should be noted that one of the factors complicating the process of studying the mechanism of thermal decomposition of quinol ethers and subsequent stages of vulcanization is the complex composition of these substances.

It is usually customary to compare the reactivity of vulcanizing agents by the values of the rate constants at a certain temperature; it is also informative to compare the conditional critical temperatures *Tcr* determined from the found Arrhenius vulcanization parameters (E≠, *J* and lgA), at which $k = 1 \cdot 10^{-6}$, s^{-1}.

Tcr values also have a technological meaning - the limiting, critical storage temperature for raw rubbers, glues or non-vulcanized products.

Comparison of the reactivity of quinol esters in the process of vulcanization of unsaturated rubbers according to the values of the conditional temperature *Tcr* and according to the data of Table 1, the ester EKh-2 has a higher reactivity in comparison with the EKh-1 ester, but only the EKh-1 ester remains available to date. In this regard, the search for accelerators for vulcanization of compositions based on unsaturated rubbers, using the quinol ester EKh-1, is an urgent task.

Theoretically, the curing activity of quinol esters can be increased by shifting the equilibrium to the right, for example, by neutralizing the resulting phenoxyl radicals according to the scheme.
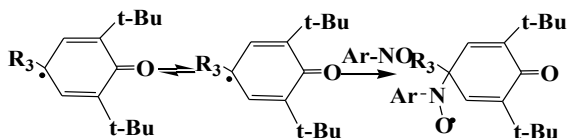
For this purpose, in our work [15], *mono*-nitrosoarenes, known as spin traps, were tested. Investigation of the kinetics of vulcanization of unsaturated rubbers with quinol ether EKh-1 in the presence of mononitrosoarenes are presented in Table 2,as well as arrhenius parameters of vulcanization, *Tcr* values, conventional strength (σ) and elongation at break (ε). It should be noted that the addition of nitrosobenzene already at the stage of rolling led to a noticeable scorching of the model mixture SKI-3, which did not make it possible to correctly estimate the Arrhenius characteristics and the value of *Tcr*. The ability of *mono*-nitrosoarenes (MNA) to cold vulcanization of unsaturated rubbers was first noted in [16].

Table 2.
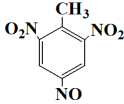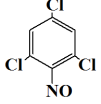
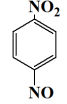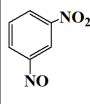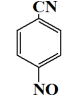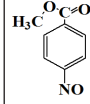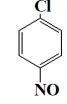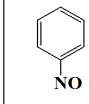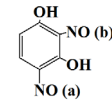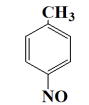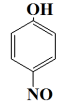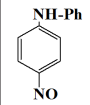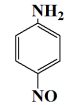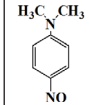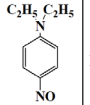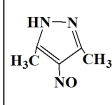*Arrhenius parameters of vulcanization and some physical and mechanical characteristics of vulcanizates*

Rubber	Molar ratio of MNA: EKh-1	$E^{\neq}$, kJ/mol	lg A	Tcr	σ, MPa	ε, %
SKI-3	-	18,8	8,7	6,1	12,3	270
	NDEA 1:1	17,2	8,1	-5,6	10,7	340
	NDEA 2:1	16,0	7,3	-9,7	10,1	245
	THNB 1:1	19,7	9,3	8,1	7,2	350
SKN-40	-	24,3	11,3	33,4	4,4	490
	NDEA 1:1	21,9	10,1	23,2	3,7	790
	NDEA 2:1	17,4	7,8	5,8	3,9	920
	THNB 1:1	21,8	10,1	19,9	4,7	420
SKEPT-ENB 40	-	23,0	10,5	31,2	4,0	160
	NDEA 1:1	18,6	8,0	18,2	3,8	165
	NDEA 2:1	17,7	7,5	14,7	3,5	190
	THNB 1:1	17,3	7,3	8,6	4,0	160

The following conclusions can be drawn from the studies carried out: NDEA (4-nitrosodiethilanilin) additive leads to acceleration of vulcanization and a decrease in *Tcr* values; The addition of nitrosoarenes to the SKI-3 composition and exposure at 100–130°C apparently led to the destruction of macromolecules and a decrease in the relative strength; On SKN-40 butadiene rubber, the introduction of THNB (1,3,5-trichlornitrosobenzene) leads to both a decrease in the *Tcr* value by 13°C and an increase by 7% in the relative strength, which deserves further research where a lower vulcanization temperature is required; NDEA and THNB proved to be the most effective as accelerators of low-temperature vulcanization with quinol ether EKh-1 model compositions SKEPT-ENB, where THNB showed the best result.

Table 3

Prediction of the accelerating ability of the vulcanization process for a number of mono-nitroso compounds from the calculated values of the charge values on the oxygen of the nitroso group

V-vo	O_2N—CH$_3$—NO$_2$ NO	Cl Cl Cl NO	NO$_2$ NO	NO$_2$ NO	CN NO	H$_3$C—O C≠O NO	Cl NO	NO
qO	-0,2518	-0,2570	-0,2610	-0,2667	-0,2670	-0,2740	-0,2820	-0,2849
V-vo	OH NO(b) OH NO(a)	CH$_3$ NO	OH NO	NH-Ph NO	NH$_2$ NO	H$_3$C N CH$_3$ NO	C$_2$H$_5$ N C$_2$H$_5$ NO	HN—N H$_3$C CH$_3$ NO
qO	-0,2827(a) -0,2991(b)	-0,2919	-0,3031	-0,3170	-0,3190	-0,3246	-0,3277	-0,3370

Comparing NDEA and THNB, it is not difficult to notice the effect of substituent groups on the reactivity of nitrosoarenes; this dependence was previously associated with the Hammett constants and with the charge on the oxygen of the nitroso group lgk=11,3+49,7qO [12]. In this regard, it has been suggested that *mono*-nitrosoarenes with strong electron-withdrawing substituent groups are highly active, both for individual vulcanizing agents and for vulcanization accelerators for compositions based on unsaturated rubbers (SKI, SKEPT, SKN, BNKS, etc.) and quinol esters (EKh -1, EKh-2).

Table 3 shows the results of calculations by the DFT B3LYP/6-31G (d) method for a number of nitrosoarenes arranged in decreasing order of the predicted accelerating ability of the vulcanization process from the calculated values of the charge on the oxygen of the nitroso group.

We can assume a certain prospect for the synthesis and testing of the vulcanizing and accelerating activity of 4-nitroso-2,6-dinitrotoluene, which has a wide raw material base based on the conversion of spent trinitrotoluene according to the general classical scheme for the synthesis of nitrosoarenes with selective reduction of nitroarene, for example, the $Zn + NH_4Cl + H_2O$, to arylhydroxylamine followed by mild oxidation according to the scheme:
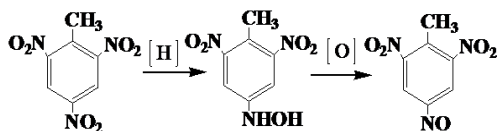
Another interesting direction in the use of quinol esters was the development of a new plastic art material for creativity, plasticine curing in rubber [17-19], which can be imagined as a direction in 3D creativity. Fig. 4 shows a volumetric rubber painting of A0 format based on V. Van Gogh's "Starry Night":
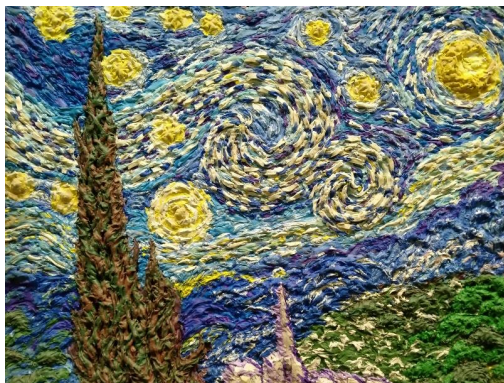

Fig. 4. *Volumetric rubber painting of A0 format based on V. Van Gogh's "Starry Night"*

The Klyuchnikovs' plasticine hardening into rubber was based on unsaturated rubber, filler, plasticizer, pigments and quinol ether EKh-1, vulcanization at 100°C for 30 min.

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3.1–7岁儿童烧伤毒血症呼吸昼夜节律的变化
CHANGES IN THE CIRCADIAN RHYTHM OF RESPIRATION IN BURN TOXEMIA IN CHILDREN AGED 3.1-7 YEARS

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抽象。在第一天发现的自发性呼吸增加趋势并未在所有被检查患者的整个毒血症整个期间偏离允许的值。第一组的儿童在第一天的昼夜节律RR的前相，顶相，下垂期的指数趋于逐渐下降至第五天的年龄正常。在毒血症发生的头十年进行强化治疗，烧伤表面和皮肤损伤的深度增加，最高2–3A，最高47.9±17.1％，最高3B，最高18.1±12.2％，IF指数最高85.1±28.7尽管在第2组儿童中，氧饱和度的昼夜节律指标令人满意，但在毒血症期第二周的治疗单位效果不佳。　2–3A烧伤的面积和深度增加至59.2±12.2％，3B烧伤的面积和深度增加至36.7±13.3％，IF指标增加至127.5±33.3单位，这导致了ARF的严重程度增加呼吸系统的炎性病变至少持续30天。

在所有组中，毒血症期间RR昼夜节律的幅度变化具有震荡性质，在第3组儿童中最为明显，也就是说，患者的病情越严重，则7天就越多在儿童严重烧伤中，RR昼夜节律幅度的3–4天波动代替了这种波动。

关键词：烧伤毒血症，昼夜节律，呼吸，儿童

Abstract. *The tendencies to an increase in spontaneous respiration, revealed on the first day, did not deviate from the permissible values throughout the entire period of toxemia in all examined patients. Indices of mesor, acrophase, bathiphase of the circadian rhythm RR on the first day in children of the 1st group tended to gradually decrease to the age norm on the 5th day. Intensive therapy in the first decade of toxemia with an increase in the burn surface and the depth of skin damage up to grade 2-3A up to 47.9±17.1%, grade 3B up to 18.1±12.2%, IF index*

up to 85.1±28.7 units in the second week of the toxemia period was insufficiently effective, despite satisfactorily stable indicators of the circadian rhythm of oxygen saturation in group 2 of children. An increase in the area and depth of a 2-3A burn to 59.2±12.2%, a 3B burn to 36.7±13.3%, an IF indicator to 127.5±33.3 units led to an increase in the degree of ARF due to the severity of the inflammatory lesion of the respiratory system for at least 30 days.

The dynamics of changes in the amplitude of the RR circadian rhythm during the period of toxemia in all groups was of an oscillatory nature, most pronounced in group 3 of children, that is, the more severe the patient's condition was, the more 7-day fluctuations were replaced by 3-4-day fluctuations in the amplitude of the RR circadian rhythm in severe burns in children.

Keywords: *burn toxemia, circadian rhythm, respiration, children*

Relevance. In children suffering from various diseases, breathing tests can reveal hidden pathological conditions and evaluate the functionality of their compensation. According to researchers, the amplitude of circadian rhythms is extremely important for assessing the functional state of a person. It was found that one of the first manifestations of fatigue (overtraining) is a violation of the chronostructure of the rhythm of hemodynamic parameters, manifested in a decrease in the amplitude of their circadian rhythm. Due to the lack of data in the literature, we made an attempt to study and evaluate the effect of burn disease toxemia on changes in the structure of the circadian rhythm of breathing in severe burns in children aged 3.1-7 years.

Purpose of the study. Examine and evaluate the changes in the circadian rhythm of the respiratory rate and oxygen saturation during the period of toxemia of burn disease in preschool children.

Clinical material and research methods. We have processed data of studies of 24 children aged from 3.1 to 7 years. Patients were considered depending on the severity and area of damage, age, duration of treatment in the ICU. Thus, the number of children in the ICU for up to 10 days was 10 (1 subgroup), 11-20 days - 8 children (2 subgroup), more than 21 days (21-54 days –6 children). The severity of the burn was assessed by calculating the surface area of the damaged skin and using the Frank index. The study was carried out by monitoring with hourly registration of parameters of respiratory rate (RR), oxygen saturation, body temperature. The data were processed by the method of variation statistics using the Excel program by calculating the arithmetic mean values (M) and the errors of the means (m). To assess the reliability of the differences between the two values, the parametric Student's test (t) was used. The interrelation of the dynamics of the studied indicators was determined by the method of paired correlations. The critical level of significance was taken equal to 0.05. Intensive therapy from the

moment of admission was aimed at removing burn shock by adequate anesthesia and intravenous administration of crystalloids, volemic solutions under the control of hemodynamics, and the volume of urine output.

Characteristics of patients aged 3.1-7 years

Groups	Body weight, kg	Age in years	Height in cm	Area of 2-3A degree burn in%	Area of 3B degree burn in%	IF in units	Duration of inpatient treatment	Number of days in the ICU
1	15,8±1,8	4,7±0,8	99,7±5,9	37,3±14,7	3,1±4,4	42,5±15,7	25,5±10,3	8,1±1,3
2	16,6±2,4	4,0±0,1	103,5±8,3	47,9±17,1	18,1±12,2	85,1±28,7	49,9±16,9	13,1±1,9*
3	16,4±2,4	4,4±0,6	107,3±9,8	59,2±12,2	36,7±13,3*	127,5±33,3*	61,8±13,5*	27,3±3,2*

The average age of children with severe burns in the age group from 3.1 to 7 years ranged from 4 to 4.7 years, height from 99.7 to 107.3 cm, body weight 15.8 - 16.4 kg (Table 1). There were no significant differences between the groups and in the index of the area of the 2-3A burn, which was 37.3±14.7% in group 1, 47.9±17.1% in group 2, and 59.2±12.2% in group 3. However, a statistically significant difference was found in the area of grade 3B burns in groups 1 and 3, which in the most severe group of children exceeded the grade 3B burn in group 1 by 11 times ($p < 0.05$) and was 6 times greater than in group 2. At the same time, the indicator of the Frank index in group 2 turned out to be two times higher than in the first (unreliable due to the large spread of the indicator in the group), and in group 3 it was significantly higher than in the first more than three times ($p < 0.05$). In accordance with the severity of the condition, the duration of intensive therapy in ICU conditions in group 2 was more than in the first by 62% ($p < 0.05$), in group 3 more than three times longer ($p < 0.05$) than in the first. According to the severity of the condition, the duration of inpatient therapy in group 1 was 25.5±10.3 days, in group 2 - 49.9±16.9, in group 3 - 61.8±13.5 days. Thus, the determining factors in the assessment of severity were such indicators as the size of the burn area of 3B degree, the Frank index, which determined the duration of intensive care in the ICU.

Results and discussion.

As can be seen from the data presented in Table 2, on the first day, the RR mesor indicator of the circadian rhythm differed from the age norm with a tendency to increase (RR norm at the age of 3.1-7 years is 25.4±1.52 per minute).

Table 2

Dynamics of mesors of circadian rhythms of respiration rate and oxygen saturation index

days	Respiratory rate per minute			Oxygen saturation in%		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
1	28,1±1,4	27,3±0,6	28,7±1,1	97,9±0,3	97,8±0,3	97,6±0,3
2	27,8±0,4	25,5±0,7*	28,1±0,3	97,9±0,1	98,0±0,3	97,7±0,3
3	26,2±0,5	25,1±0,5*	27,9±0,5‴	98,0±0,2	97,8±0,5	98,1±0,3
4	26,2±0,4	28,2±0,5	27,7±0,4	98,1±0,2	98,1±0,2	98,2±0,2
5	25,0±0,3*	26,9±0,5	27,3±0,4	97,8±0,1	97,4±0,3	97,7±0,2
6	26,6±0,4	26,3±1,0	28,2±0,6‴	98,2±0,2	98,1±0,2	97,9±0,2
7	24,9±0,5*	27,1±0,5	27,8±0,8	97,5±0,3	97,9±0,2	98,0±0,2
8	26,5±0,4	26,2±0,4	27,6±0,3‴	97,8±0,2	98,1±0,2	98,2±0,2
9	25,6±0,7*	27,7±1,1	27,3±0,5	98,2±0,3	97,8±0,3	98,0±0,2
10		27,9±0,5	27,3±0,5		97,8±0,2	98,1±0,2
11		27,0±0,6	28,2±0,4‴		98,1±0,3	98,0±0,2
12		27,5±0,8	28,5±0,4		98,0±0,2	98,2±0,2
13		28,2±0,9	28,3±0,6		98,0±0,5	98,0±0,3
14		29,6±0,9	28,4±0,3		98,1±0,4	97,5±0,2
15		30,4±1,1*	28,6±0,6		98,1±0,3	98,0±0,3
16		27,8±0,4	30,1±0,6‴		97,5±0,8	97,8±0,2
17			29,0±0,3			97,8±0,2
18			30,4±0,4			98,0±0,2
19			31,8±0,7			98,0±0,3
20			29,9±0,5			98,0±0,3
21			29,9±0,4			97,7±0,2
22			30,0±0,6			97,5±0,2
23			29,8±0,4			97,9±0,2
24			31,0±0,9			98,0±0,3
25			30,1±0,6			97,9±0,2
26			29,6±0,8			97,9±0,3
27			30,1±0,3			98,0±0,2
28			30,4±0,6			97,8±0,2
29			28,4±0,6			98,0±0,3
30			27,3±0,7			97,9±0,4

*- reliable relative to the indicator in 1 day

‴- reliable relative to the indicator in the previous group

In dynamics, monitoring during the period of toxemia revealed a significant decrease in RR on days 5, 7, 9 by 10% (p <0.05, respectively). In group 2, a decrease in RR was detected as early as 2.3 days by 7% (p <0.05). On the 15th day, patients in group 2 showed an 11% increase in RR (p <0.05). In group 3, more frequent breathing was maintained throughout the observation period than in the first two groups. So, on days 3,6,8,11, 16, the indicator of the mesor of the circadian rhythm RR was significantly higher than in group 2 by 8%; 7.6%; 5% ; 4%; 8% (p<0.05, respectively). Tendencies to an increase in spontaneous respiration were revealed, the mesor of the circadian rhythm of oxygen saturation did not deviate from the permissible values throughout the entire period of toxemia in all examined patients. Thus, the correspondence of oxygen saturation to the normative values characterized a sufficient compensatory functional activity of the respiratory system in severe burn injury in children aged 3.1-7 years.

However, in the process of analyzing the dynamics of the circadian characteristics of respiration and oxygen saturation, some features were revealed. Thus, the highest indices of mesor, acrophase, bathiphase of the circadian rhythm RR on the first day (Fig. 1) in children of group 1 tended to gradually decrease to the age norm on the 5th day.

Fig.1

Dynamics of the structural characteristics of the circadian rhythm of respiration during the period of toxemia in children of the 2nd group of preschool age (HR per minute)
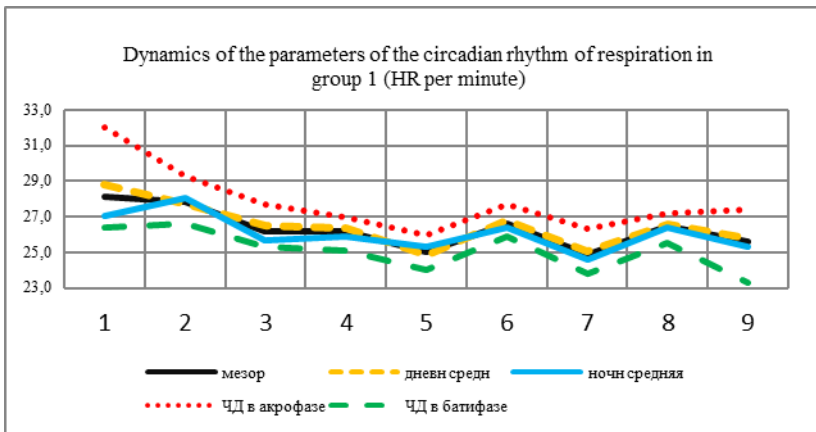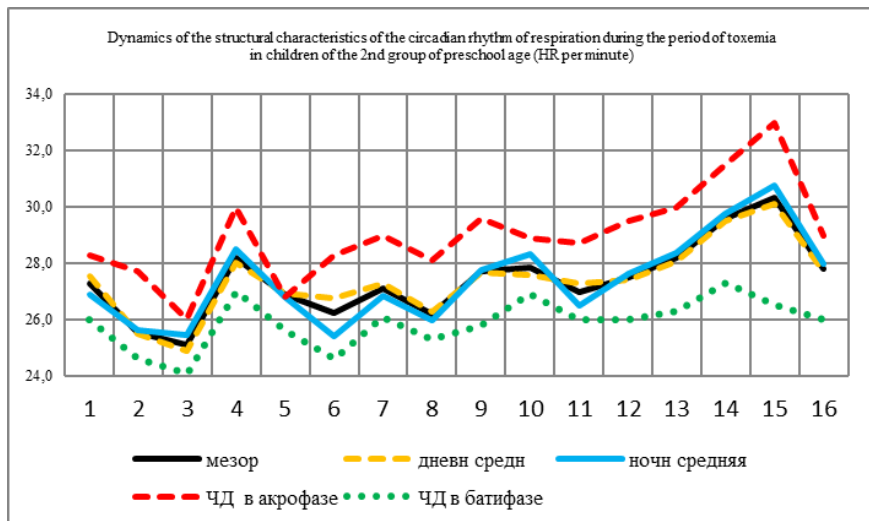
Fig.2

In group 2 (Fig. 2), changes in the parameters of the RR circadian rhythm were also wavy in nature with a wave peak on day 4.15. That is, with an increase in the area of the burn surface of 2-3A degree up to 47.9±17.1%, 3B degree up to 18.1±12.2%, IF indicator up to 85.1±28.7 units, the load on the respiratory system significantly increased, which, against the background of general intoxication, led to the development of pneumonia. Acute respiratory failure, increasing on the 15th day (an increase in the mesor and RR in the acrophase of the average daily and midnight RR by 20%), confirmed by X-ray examination data, laboratory blood tests indicated pneumonia. Thus, we can say that the etiopathogenetically grounded routine therapy, carried out in the first decade of toxemia with an increase in the burn surface and the depth of skin damage of 2-3A degree to 47.9±17.1%, 3B degree to 18.1±12.2%, IF indicator up to 85.1±28.7 units in the second week of the toxemia period was insufficiently effective despite satisfactorily stable indicators of the circadian rhythm of oxygen saturation in group 2 of children.
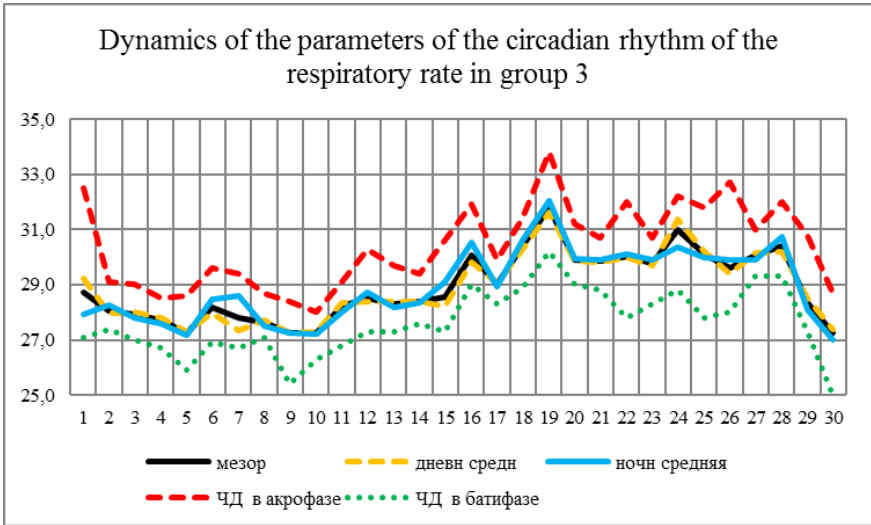
Fig.3

The RR circadian rhythm in group 3 differed from the first two groups in the large values of the parameters of the circadian rhythm of respiration already in the first day by 16%. In Fig. 3, seven-day periods of fluctuations can be distinguished, and after 14 days, along with an increase in mesor and amplitude, three-day fluctuations were more clearly indicated. An increase in the area and depth of a 2-3A burn to 59.2±12.2%, a 3B burn to 36.7±13.3%, an IF index to 127.5±33.3 units caused acute respiratory failure as early as 1 day with an increase of the mesor in the first 10 days by 12%, in the next 12-28 days the level of the mesor of the circadian rhythm RR on the 19th day increased by 36% ($p<0.05$). Thus, on the basis of the revealed changes in the parameters of the RR circadian rhythm, it can be concluded that an increase in the area and depth of a 2-3A burn to 59.2±12.2%, a 3B burn to 36.7±13.3%, an IF indicator to 127.5±33.3 units leads to an increase in the degree of ARF due to the severity of the inflammatory lesion of the respiratory system during the 30-day period of toxemia. The ongoing complex multimodal therapy allowed the level of the circadian rhythm characteristics of the oxygen saturation index to be maintained at a level above 97%, which significantly influenced the effectiveness of general therapy, surgical correction of tissues damaged by thermal burns. However, in order to reduce structural damage to the respiratory system by prolonged severe pneumonia, it may be advisable to increase the duration and qualitatively improve the detoxification, metabolite, membrane-stabilizing correction during the period of toxemia in group 3 of preschool children.
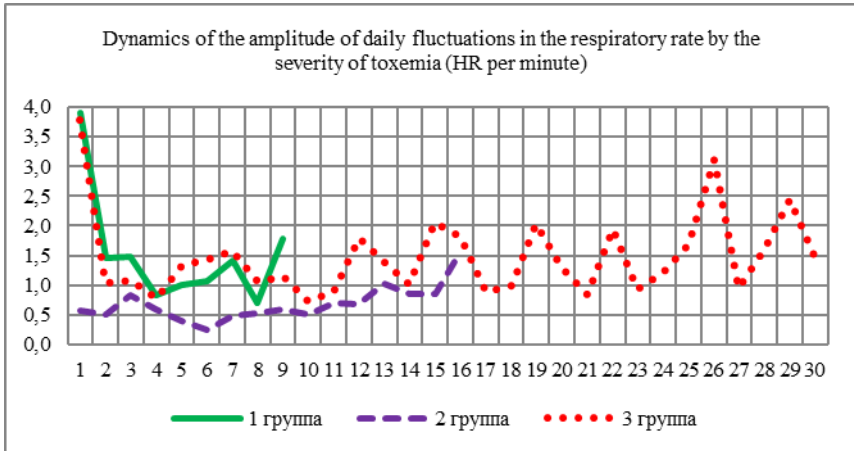
Fig.4

As is known, the indicator of the amplitude of the circadian rhythm is an indicator of functional tension during stress. Thus, in Fig. 4 it can be seen that the greatest increase in the amplitude of daily RR fluctuations was observed in group 3. While in group 1 on day 1, a maximum amplitude of 4 breaths per minute was found, and in group 2 on day 1, 0.5 breaths per minute. The dynamics of changes in the amplitude of the circadian rhythm RR during the period of toxemia in all groups was of an oscillatory nature, most pronounced in group 3 of children with a period of oscillation of 4 - 3 days. That is, the more severe the patient's condition, the more 7-day periods of fluctuations were replaced by 3-4-day fluctuations in the amplitude of the circadian rhythm RR in severe burns in children.
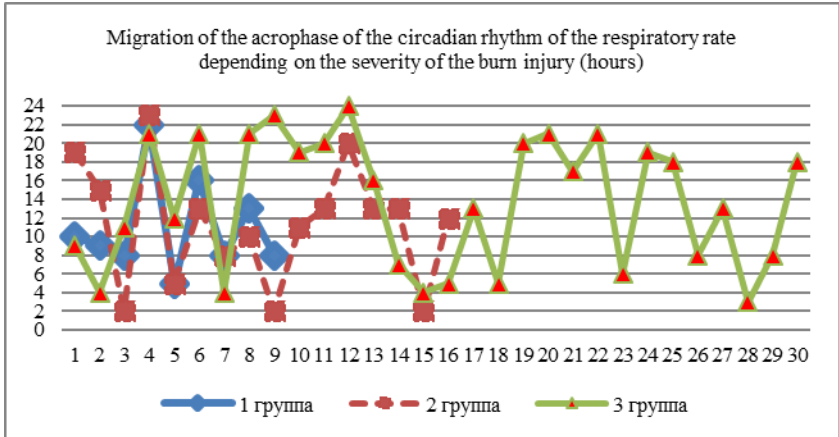
Fig.5

Interesting data was obtained when analyzing migration on the RR dial in acrophase.

Normal projection in the morning hours (9-12 hours) was detected in group 1 for 5 days out of 9 (55% of the time of toxemia), a moderate shift of the second degree (13-22 hours) for 3 days (34%), and inversion of the circadian rhythm RR within 1 day (11%). In group 2, the norm was detected for 2 out of 16 days (12%), a moderate shift - 7 days (44%), inversion - 7 days (44%). In group 3, the normal position of the RR acrophase was detected within 3 days out of 30 (10%), a moderate shift - 15 days (50%), inversion - 12 days out of 30 (40%). Thus, the normal projection of RR acrophase prevailed in group 1 (55%), inversion of the RR circadian rhythm in groups 2 and 3 of burned children, accounting for 44% and 40% of the period of toxemia. An interesting fact is that there is no direct relationship between the degree of RR acrophase shifts in terms of burn severity. So in group 1, the normal position of the acrophase of oxygen saturation was 55%, as well as RR. However, in groups 2 and 3, moderately pronounced migration of the peak of acrophase RR over 44% (9 out of 16), 43% (13 out of 30 days) was predominant.
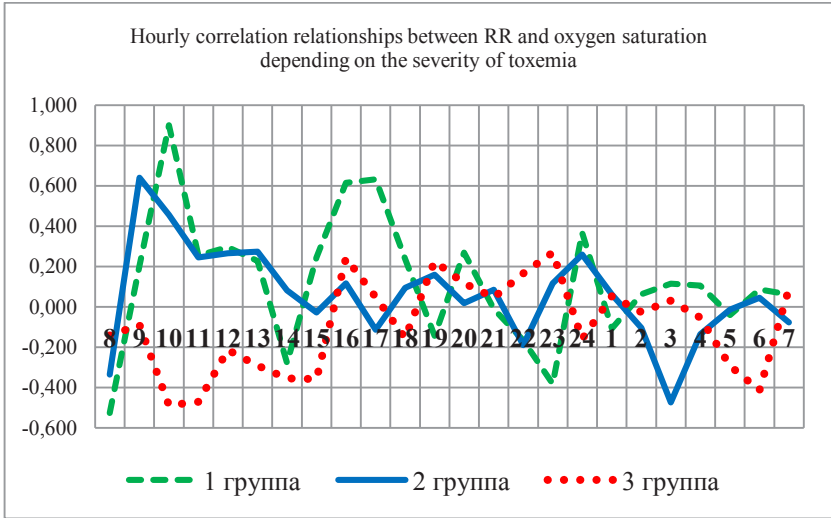
Fig.6

As can be seen from the data presented in Fig. 6, the prevailing moderate correlations were positive, a reliably significant correlation between RR and oxygen saturation index was found only in children of group 1 at 10 a.m.
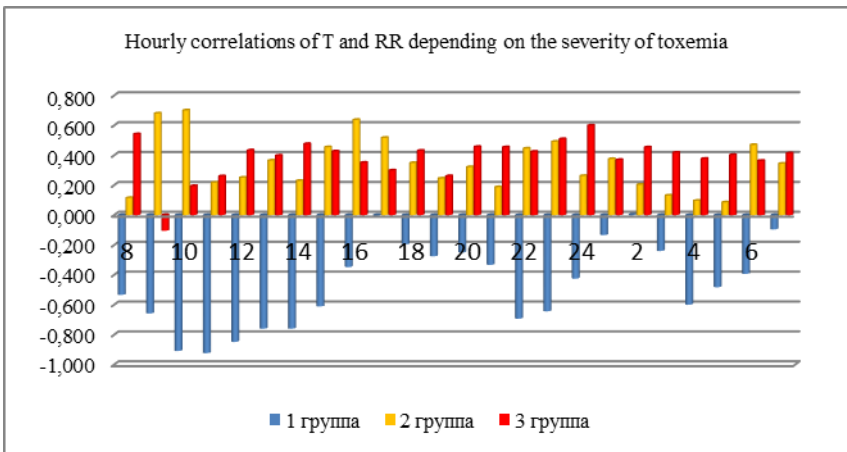
Fig.7

As can be seen from the data in Fig. 7, the dynamics of the T° and RR correlations during the day had a wavy character. The most pronounced negative dependence of RR on T° was found in group 1 in the morning hours (9-14 hours) and less pronounced at night (22-23 hours). That is, at the indicated time of the day during the period of toxemia in group 1, increased respiration led to a decrease in temperature, that is, breathing in children of group 1 was more of a compensatory nature. While in the 2 (9-10 am) and 3 (24 hours) groups of children, the increase in respiration was due to the severity of the inflammatory process in the respiratory system, when the increase in body temperature was accompanied by increased respiration.
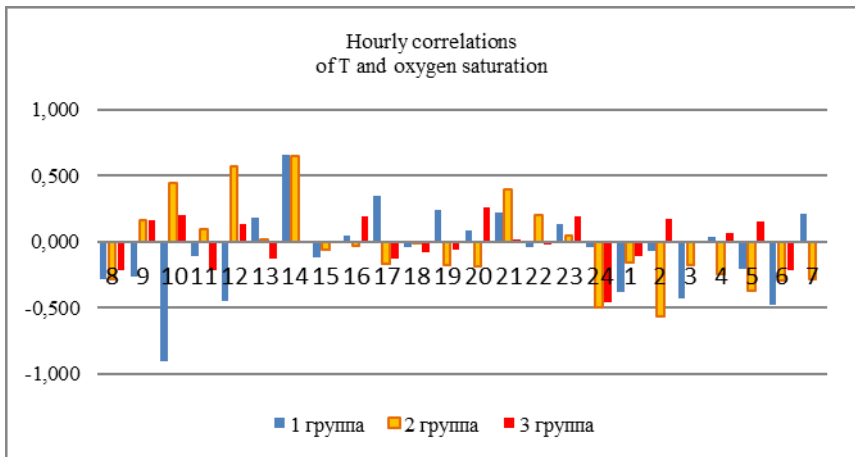
Fig.8

Figure 8 shows the degree of hourly correlations of T°C and oxygen saturation throughout the day. Thus, in group 1, a reliably significant inverse correlation was observed at 10 am, that is, a decrease in body temperature maintained the required level of hemoglobin oxygenation. In group 2, a moderate correlation was found at 12 and 14 noon, in group 3, correlations between body temperature and oxygen saturation index were not revealed.

Conclusion. The tendencies to an increase in spontaneous respiration revealed in the first day, the indicators of the mesor of the circadian rhythm of the oxygen saturation indicator did not deviate from the permissible values throughout the entire period of toxemia in all examined patients. Indices of mesor, acrophase, batiphase of the circadian rhythm RR on the first day in children of group 1 tended to gradually decrease to the age norm on the 5th day. Intensive therapy in the first decade of toxemia with an increase in the burn surface and the depth of skin damage

up to 2-3A degree up to 47.9±17.1%, 3B degree up to 18.1±12.2%, IF indicator up to 85.1±28.7 units in the second week of the toxemia period was insufficiently effective, despite satisfactorily stable indicators of the circadian rhythm of oxygen saturation in group 2 of children. An increase in the area and depth of a 2-3A burn to 59.2±12.2%, a 3B burn to 36.7±13.3%, an IF index to 127.5±33.3 units led to an increase in the degree of ARF due to severity of inflammatory lesions of the respiratory system for at least 30 days.

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痤疮的病因，发病机制和统计数据
ETIOLOGY, PATHOGENESIS AND STATISTICS OF ACNE

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抽象。 该文章详细介绍了痤疮的流行病学，分类，发病机理和临床表现的现代数据。 介绍和分析痤疮的分类和统计数据。
关键词：皮疹，痤疮，因素，分类，诊断，治疗。

Abstract. *The article presents in detail modern data on the epidemiology, classification, pathogenesis and clinical picture of acne. The classification and statistics of acne are presented and analyzed.*

Keywords: *rash, acne, factors, classification, diagnosis, therapy.*

Acne (Acne Vulgarus) is a disease in which the hair follicles and sebaceous glands located on the skin of a person become inflamed. Usually, the disease affects those areas where the largest number of sebaceous glands is located. These are the back, chest and face.

Acne is a fairly common skin disease. Statistical data indicate that about 80% of people in the age group 12-25 years old suffer from this disease, and about 30-40% of people who are over 25 years old. From this we can conclude that this disease is "maturing". This fact determines the relevance of the issue under consideration and the need to create modern drugs and treatment regimens for the disease. In more than 1/3 of cases, this disease requires serious and often long-term treatment by specialists in this field [4, p.54].

Rosacea - is a chronic skin disease that manifests itself as erythema (redness) of the skin, telangiectasias, and papules and pustules that resemble common acne. Due to the latter, this disease is also called "rose drop". Rosacea occurs mainly in the middle third of the face, as well as in the forehead, nose and chin. In rare cases, it can occur outside the face - mainly on the neck, chest, scalp, or ears.

A predisposing factor for the appearance of rosacea is, for example, exposure to solar UV radiation, which stimulates the production of vascular endothelial growth factor and leads to the appearance of small capillary networks, i.e. telangiectasias. Accordingly, rosacea can easily appear after a tanning bed. Other factors

are a genetic predisposition (associated with the lability of the walls of blood vessels), as well as an individual tendency of a person to reddening of the skin, which is associated, among other things, with the superficial location of blood vessels [3, p.94].

There are many causes of acne in both men and women in adults. It can be:

Sebaceous duct hyperplasia, due to which the sebaceous glands increase in size and produce more sebum.

Endocrine diseases, in particular adrenal hyperplasia, in which hormonal imbalance occurs in the body. As a result of such a failure, a person has an increased "hairiness" of the skin and excessive production of sebum.

Poor-quality unbalanced nutrition and impaired functioning of the digestive tract can also provoke a skin rash. The condition of the skin is a kind of indicator of the work of internal organs. Diseases of the stomach and intestines can also manifest themselves as acne and pallor of the skin. Worm infestations can also provoke the appearance of acne [2, p.16].

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Poor-quality unbalanced nutrition and impaired functioning of the digestive tract can also provoke a skin rash. The condition of the skin is a kind of indicator of the work of internal organs. Diseases of the stomach and intestines can also manifest themselves as acne and pallor of the skin. Worm infestations can also provoke the appearance of acne [1, p.80].

Rosacea is not a cosmetic problem, but a dermatological one. Its symptoms have been known for several hundred years, but its causes are still not clear. Its manifestations, various external and internal factors that aggravate them are described in detail, a lot of modern scientific data have been collected on the study of the biological mechanisms of the disease at the cellular and molecular level, but it has not yet been possible to link all this into a single pathophysiological picture. Even the final name for this systemic skin disease "rosacea" was coined relatively recently.

The occurrence of rosacea can be influenced by - 1) parasitic skin disease caused by mites Demodex folliculorum, as well as bacteria Staphylococcus epidermidis, 2) gastrointestinal diseases associated with intestinal infection with Helicobacter pylori bacteria. In studies, it was found that in the presence of intestinal inflammation and Helicobacter pylori, hypersensitization of sensitive neurons in the face area occurs (through the synthesis of bradykinin, which is a powerful vascular dilator).

Most often, the disease is detected in patients 30-50 years old, and according to statistics, it occurs in 10% of the population. It has been noted that rosacea is more common in people with fair skin who blush easily. Most often these are women with fair skin, blond hair and blue eyes. In men, the disease develops less frequently, but phimatous changes develop more often. Depending on the clinical manifestations of rosacea, it is customary to divide into 4 types, which we will discuss below.

Rosacea symptoms usually begin with erythema, a persistent, temporary redness on the cheeks, nose, forehead, or chin. Or another option - redness can be observed in the form of frequent fast-passing outbreaks of facial redness, which are commonly called the term "hyperemia". In both cases, the resulting redness may be accompanied by a sensation of warmth or burning. Over time, periods of redness of the skin become longer and more intense.

In parallel with this, visible small blood vessels appear on the skin of the face, which are usually called telangiectasias or spider veins. If untreated, inflammatory elements begin to appear - papules or pustules (they look like ordinary purulent acne). In severe cases, the skin may gradually begin to thicken, in which case it also becomes loose. This can lead to disfigurement of the face. If this process occurs on the nose, then it is called the term "rhinophyma".

Rosacea affects the eyes in about 50% of patients, causing them to appear irritated, swollen, or bloodshot. If left untreated, this inflammation can lead to corneal damage and loss of visual acuity. All of the above symptoms are the main ones.

Also, researchers distinguish minor signs of rosacea, which, however, do not appear in isolation, but in combination with one or more of the main signs. This can be a burning or itching sensation of the skin on the face. Or it may be red spots slightly rising above the skin surface (in the form of plaques). Or, the skin in the middle third of the face may look dry, rough, and flaky. [2, p.31].

In addition to these factors, the influence can be exerted by - 1) parasitic skin disease caused by mites Demodex folliculorum, as well as bacteria Staphylococcus epidermidis, 2) gastrointestinal diseases associated with intestinal infection with Helicobacter pylori bacteria. In studies, it was found that in the presence of intestinal inflammation and Helicobacter pylori, hypersensitization of sensitive neurons in the face area occurs (through the synthesis of bradykinin, which is a powerful vascular dilator).

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Taking into account this classification, dermatologists distinguish a classification according to the severity of acne, which is of great importance in determining the local and systemic therapy of acne.

The concept of etiology and pathogenesis in the study of acne is difficult to separate. The close connection between provoking and predisposing factors leading to the formation of acne does not make it possible to clearly separate these concepts. However, some lines can be drawn.

So, the predisposing factors include:
– heredity
– hormonal activity (menstruation, puberty), hormonal disruptions
– poor skin care, insufficient cleansing
– diseases of the gastrointestinal tract (gastrointestinal tract)
– transitional age
- stress that activates the adrenal glands
The provoking factors of acne include:
– demodicosis (acne mite).
– inflammation;
– reproduction of Propionibacterium acnes;
– follicular hyperreactivity;
– excess secretion of fat by the sebaceous glands.

The combination of these factors leads to the activation of the links of the complex pathogenesis of acne [5, p.63].

We would also like to dwell on demodicosis (acne mite). Being a resident of healthy human skin, when a certain amount is exceeded, this mite can cause severe acne with the formation of scar tissue on the face. A subcutaneous mite on the face is called demodex or acne.

It is a small arthropod that lives in the sebaceous glands and hair follicles of humans.

Its size varies from 0.1 to 0.4 mm. Normally, it is present in every person - no more than 2-3 individuals per square centimeter. In small quantities, the mite does not harm the body, on the contrary, it serves to maintain the acid-base balance of the skin in normal conditions. But when exposed to certain factors, the mite begins to multiply actively, and this leads to pronounced negative changes in the skin of the face.

The characteristic signs (symptoms) of demodicosis include:

– an increase in the nose;

– itching;

– redness of the skin;

– acne; – oily sheen.

These data are essential in establishing the etiology of acne. Examination and diagnosis of acne patients.

One of the most important points in the diagnosis of acne, along with the examination, is the collection of anamnesis in patients with acne. Attention should be paid to the patient's family and personal history.

So, in the family history, it is important to find out the presence of a genetic predisposition to diseases of the endocrine and reproductive systems. In the history, it is important to find out the time of onset of the disease and puberty of patients.

Particular attention should be paid to the age of onset of menarche and the nature of menstruation. When collecting anamnesis in patients with acne, it is necessary to clarify information about past diseases, the presence of foci of focal infection.

It is also important to pay attention to such anamnestic data as professional activity, duration of illness, effectiveness of previous treatment, psychological status and patient adherence to treatment. When examining a patient, height, weight, body type are assessed, since, for example, overweight may be a sign of endocrine pathology.

Rosacea is often referred to as "rose drop", although acne and rosacea are very different conditions. Acne is characterized by oily skin, onset at a young age. Rosacea is observed, as already mentioned, after 30 years and is not always accompanied by seborrhea, i.e. increased secretion of sebum. But at a certain stage, these diseases are similar and only a dermatologist can distinguish them.

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中枢神经系统功能状态的动力学特征及丝纺生产中妇女的注意功能
CHARACTERISTICS OF THE DYNAMICS OF THE FUNCTIONAL STATE OF THE CENTRAL NERVOUS SYSTEM AND THE FUNCTION OF ATTENTION OF WOMEN WORKING AT SILK SPINNING PRODUCTIONS

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抽象。 纺丝工业中的工作条件和劳动过程的性质导致在职妇女在中枢神经系统中主要表现为抑制过程，持续的抑制作用，分化错误的增加，功能的下降注意，表明生产疲劳。 夏季工作场所空气温度升高时，指标的变化更加明显。
关键词：丝绸织造，工作条件，中枢神经系统，注意功能，疲劳。
Abstract. Working conditions and the nature of labor processes in silk-spinning industries cause in working women the development of a predominance of inhibitory processes in the central nervous system, consistent inhibition, an increase in errors in differentiation, a decrease in the function of attention, which indicates production fatigue. At elevated air temperatures at workplaces in the summer, changes in indicators are more pronounced.
Keywords: silk weaving, working conditions, central nervous system, attention function, fatigue.

The silk processing industry in Uzbekistan is one of the most developed sectors of the national economy. Large capacities for the production of silk are concentrated in Uzbekistan. In the cities of Fergana, Margilan, Bukhara, Namangan, Urgench, Andijan and others, there are large silk-weaving mills and factories, which mainly employ women. Joint ventures equipped with new imported equipment are being created, new modern technologies are being introduced, which leads to a change in working conditions at enterprises of the silk industry, to an increase in the intensity, neuro-emotional tension and intellectuality of labor processes.

The purpose of the study was to study the working conditions of modern silk-spinning industries and their influence on the dynamics of indicators of the central nervous system and attention function of working women.

Research methods. Working conditions were studied by traditional methods using an aspirator, psi-chromometer, anemometer, sound level meter, lux meter in accordance with the requirements of the Sanitary Rules, Norms and Hygienic Standards of the Republic of Uzbekistan № 0294-11 [1], 0325-16 [2], 0141-03 [3], 0324-16 [4], building codes 2.01.05-96 [6], as well as the methodology "Methodology for assessing working conditions and certification of workplaces for working conditions" [5].

The physiological reactions of the central nervous system were studied in the following order: before the start of work, the initial, background characteristics of the indicators were recorded, and at the end of the shift - the physiological reactions that developed during the working day. All measurements were made directly at workplaces in the spring period of the year, when the microclimate indicators at workplaces were optimal, and in the summer with increased air temperatures (33-34°C).

To assess changes in the central nervous system, the speed of the visual and auditory-motor reaction (VMR and AMR) was determined using a chrono-reflexometer apparatus. The attention function was studied using correction tables with a regulated text.

Working conditions of women employed in silk spinning industries (spinners, winders and twisters) were studied at the Namangan enterprises of "Atlas" JSC, the Uzbek-Japanese JV "SilkRoad", the most modern and reconstructed enterprises of the Republic of Uzbekistan.

Research results. It was found that in the process of production activities, workers in silk-spinning industries are exposed to the adverse effects of silk dust, noise, insufficient illumination, heating microclimate, the severity and intensity of the labor process, working conditions are classified as third class of third degree of hazard.

The research results show (table 1) that at the beginning of work, the time of a simple visual-motor reaction among spinners was on average 289±4.0 milliseconds, by the lunch break it increased to 308±5.1 milliseconds, and by the end of the shift to 312±6.1 milliseconds, i.e. by 7.9% compared to the background. During the summer observation period, the reaction time in the dynamics of work increased by 9.8%. The sequential VMR time in the shift dynamics also increases by 5.4% in spring and 9.9% in summer. In addition, there is a tendency towards an increase in erroneous reactions to a differentiating stimulus.

In winders, in the dynamics of the shift, the time of the visual - motor reaction increases from 326 to 346 mlsec (6.7%) in the spring period of observations and from 298 to 312 mlsec (4.6%) in the summer period. At the same time, the sequential VMR time also increases from 351 to 431 milliseconds (22.75%) in spring and from 321 to 429 (33.6%) in summer, in addition, the percentage of erroneous reactions to the differentiating stimulus increases.

In the spring period of observations, the time of simple VMR increases by 7.1% by the end of the shift, in the summer by 7.6%, consecutive by 30.9 and 47.3% on average, the number of errors per differentiating stimulus significantly increases.

Consequently, the uniform nature of the work processes of spinners, winders and twisters of silk-spinning industries, produced in conditions of insufficient light and requiring workers to exert their eyesight and attention, causes significant fatigue in working women, which manifests itself in the development of a predominance of inhibitory processes in the central nervous system, consistent inhibition and an increase in errors on differentiation, and at elevated air temperatures at workplaces, the change in indicators is more pronounced.

Taking into account that noise is one of the leading unfavorable production factors of silk spinning, in the dynamics of the working day, the indicators of the auditory - motor reaction of women of the main professional groups were studied (Table 2).

Research results show that in all occupational groups, from the beginning to the end of the shift, there is an increase in the time of both simple and complex auditory-motor response (AMR). If at the beginning of work, the AMR idle time ranged from 210 to 236 milliseconds on average, then by the lunch break it increased to 232-278 milliseconds, and by the end of work up to 256-312 milliseconds, i.e. the rate of simple AMR in the dynamics of work significantly ($p < 0.001$) decreased in all professional groups. It is noteworthy that the idle time of AMR was higher for both the background and the dynamics of work than in other professional groups, i.e. their reaction speed was lower, which is apparently due to the fact that during work they are exposed to higher noise levels (94 dB), which is manifested by an adequate reaction of the body - a pronounced manifestation of the predominance of inhibition as a sign of industrial fatigue. This is also manifested by the fact that while for spinners the idle AMR speed in the dynamics of work decreased by 26.4%, for winders by 20.7%, then for twisters by 32.2% on average.

In addition, in the dynamics of work in women of all examined professional groups, the rate of complex AMR decreased and the percentage of errors for the differentiating stimulus increased, which was a manifestation of the developing sequential inhibition and deterioration of differentiation.

In the summer period of observations, the background working time indices for both simple and complex AMR were higher than in the spring, which is apparently due to the fact that high both external and internal air temperatures cause more pronounced inhibitory processes in the central nervous system. In the dynamics of work, the AMR idle time significantly increases on average from 225 to 328 milliseconds for spinners, from 230 to 290 milliseconds for winders, and from 310 to 375 milliseconds for twisters. In addition, in all professional groups, the percentage of errors for the differentiating stimulus increases. If at the beginning of the working day this indicator in various professional groups fluctuated on

average from 4.8 to 6.8%, by the lunch break from 6.8 to 8.2%, then by the end of the shift from 8.9 to 9.6%, which indicates a deterioration in differentiation, i.e. decreased attention.

Table 1. Changes in the indicators of visual-motor reaction (VMR) among female workers of silk-spinning industries in the spring and summer periods of observations

Indicators ofVMR	Period of the year	At the beginning of work	Before lunch break	At the end of work	Reliability
		M±m	M±m	M±m	p<$_{3.5}$
1	2	3	4	5	6
Spinners					
Speed of visual - motor reaction (mlsec) - simple					
	spring	289±0,4	308±5,1	312±6,1	0,001
- consistent	summer	293±2,1	310±2,3	322±2,4	0,001
Erroneous	spring	402±8,6	406±5,2	424±7,1	0,001
reactions (%)	summer	403±4,3	425±6,1	443±5,3	0,001
	spring	5,8±0,3	7,0±0,2	7,0±0,2	-
	summer	6,3±0,1	8,0±0,2	7,3±0,2	-
Winders					
Speed of visual – motor reaction (mlsec) - simple					
	spring	326±5,5	338±5,4	346±5,8	0,05
- consistent	summer	296±4,1	289±4,1	312±4,0	0,05
Erroneous	spring	351±9,2	335±6,7	431±8,1	0,001
reactions (%)	summer	321±7,8	310±5,7	429±5,3	-
	spring	5,8±0,5	5,9±1,4	8,8±1,2	-
	summer	7,6±0,8	7,9±0,8	8,8±1,2	-
Twisters					
Speed of visual - motor reaction (mlsec) - simple					
	spring	307±4,2	323±5,1	329±5,3	0,01
- consistent	summer	248±3,6	249±4,3	267±3,7	0,05
Erroneous	spring	326±2,7	370±4,8	427±3,2	0,001
reactions (%)	summer	262±3,4	267±2,9	386±2,7	0,001
	spring	5,9±0,5	4,9±0,3	7,9±0,2	0,05
	summer	4,9±0,4	6,9±0,6	8,2±0,4	0,01

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Table 2. Changes in indicators of auditory - motor response (AMR) among female workers of silk-spinning industries in the spring and summer periods of observations

Profession	AMR indicators (mlsec)	At the beginning of work	Before lunch break	At the end of work	Reliability
		M±m	M±m	M±m	p<3-5
1	2	3	4	5	6
Spring period					
Spinners	Simple	210±2,2	246±3,3	266±3,7	0,001
	Complex	232±4,1	258±3,6	290±4,!	0,001
Winders	% of errors	4,8±0,7	7,1±0,3	9,1±0,4	0,01
	Simple	212±4,3	232±4,6	256±5,1	0,001
Twisters	Complex	228±3,7	246±3,4	272±3,2	0,001
	% of errors	4,5±0,5	5,7±0,4	7,2±0,3	0,01
	Simple	236±2,6	278±2,7	312±4,1	0,001
	Complex	286±3,2	298±4,1	334±5,2	0,001
	% of errors	6,7±0,6	6,8±0,7	12,4±0,8	0,001
Summer period					
Spinners	Simple	225±3,6	290±4,7	328±5,1	0,001
	Complex	283±3,3	315±4,3	346±3,6	0,001
Winders	% of errors	5,4±0,3	7,3±0,4	9,1±0,5	0,001
	Simple	230±3,2	243±3,6	290±4,1	0,001
Twisters	Complex	252±3,8	267±2,8	319±2,6	0,001
	% of errors	4,8±0,2	6,9±0,4	8,9±0,3	0,001
	Simple	280±4,1	315±4,2	360±6,1	0,001
	Complex	310±4,3	340±4,6	375±3,7	0,001
	% of errors	6,8±0,4	8,2±0,3	9,6±0,4	0,05

It was also found that in the dynamics of work, the indicators characterizing the function of attention of working women deteriorate (Table 3): the number of errors made increases, the actual productivity decreases, the time taken to complete the task increases, in the summer observation period the quality of the correction test performance deteriorates, and the level of working capacity below, indicating more pronounced work fatigue.

Table 3. Change in the indicators of proofreading test among female workers of the main professional groups of silk-spinning industries in the spring and summer seasons

Indicators of proofreading test	At the beginning of work	Before lunch break	At the end of work	Reliability
	M±m	M±m	M±m	$p <_{2-4}$
1	2	3	4	5
Spring period:				
- task execution time (per sec)	62,3±1,2	65,1±1,1	69,1±1,3	0,001
- the number of crossed out characters	55,4±1,7	53,6±1,6	52,5±0,7	-
- number of mistakes	1,1±0,1	1,6±0,2	2,0±0,1	0,001
- actual performance	430±1,6	428±1,1	421±2,1	0,01
Summer period				
- task execution time (per sec)	68,8±0,9	69,5±0,5	71,8±1,0	0,05
- the number of crossed out characters	51,9±1,5	53,9±1,1	54,6±1,1	-
- number of mistakes	1,1±0,03	1,6±0,1	2,6±0,1	0,001
- actual performance	433±1,6	427±1,3	406±1,1	0,01

Research materials were used in the development of methodological recommendations "Improvement of working conditions of women working in the silk-spinning industries of Uzbekistan."

Conclusions.

1. Working conditions and the nature of labor processes in silk-spinning industries cause among working women the development of a predominance of inhibitory processes in the central nervous system, consistent inhibition and an increase in errors in differentiation, and at elevated air temperatures at workplaces, changes in indicators of a simple and complex visual-motor reaction are more pronounced.

2. In the dynamics of the working day, the development of inhibitory processes was also revealed in terms of a simple and complex auditory-motor response, moreover, more pronounced shifts were noted in those professional groups where higher noise levels at workplaces (twisters) were noted, as well as at higher ambient temperatures;

3. In the dynamics of work, the indicators characterizing the function of attention of working women deteriorate: the number of errors made increases, the actual productivity decreases, the time spent on completing the task increases, in the summer observation period the quality of the correction test deteriorates, and the level of performance is lower, which indicates a more pronounced production fatigue.

4. To improve and stabilize the performance dynamics of the central nervous system of working women, it is necessary to introduce recommendations for improving working conditions, rationalizing work and rest regimes.

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牙科计算机断层扫描对糖尿病患者上颌骨组织状态的影响
FEATURES OF THE STATE OF THE BONE TISSUE OF THE UPPER JAW IN PATIENTS WITH DIABETES MELLITUS ACCORDING TO DENTAL COMPUTED TOMOGRAPHY

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Purpose of the study: analyze the condition of the bone tissue of the alveolar processes of the upper jaw using dental computed tomography in patients with diabetes mellitus.

抽象。 在研究过程中，使用计算机断层扫描技术分析了上颌牙槽突的骨结构密度。 这项技术使您可以确定骨组织的密度，从而可以准确评估糖尿病患者骨骼的定性和定量状态。

已经证明，颌骨的结构组织和骨密度取决于并发症的存在和糖尿病的发生率。 该研究发现，糖尿病患者颈部的骨密度降低，而牙齿中根三分之一的变化不太明显。 在根尖区域发现轻微的骨降解或硬化。

基于牙科计算机断层扫描的诊断对于检测糖尿病颌骨组织中的结构变化最为有用。

关键词: 骨组织的光密度，牙科计算机断层扫描，糖尿病。

Abstract. In the course of the study, the density of the bone structure of the maxillary alveolar processes was analyzed using computed tomography. This technology allows you to determine the density of bone tissue, which makes it possible to accurately assess the qualitative and quantitative state of the bones of the skeleton in diabetes mellitus.

It has been proven that the structural organization and bone density of the jaws depend on the presence of complications and the rate of diabetes mellitus. The study found a decrease in bone density in the neck area and less pronounced changes in the middle third of the roots of the teeth in people with diabetes. Minor bone degradation or hardening was found in the apex area.

Diagnostics based on dental computed tomography is the most informative for detecting structural changes in the jaw bone tissue in diabetes mellitus.

Keywords: *optical density of bone tissue, dental computed tomography, diabetes mellitus.*

Introduction. In Russia, over the past few decades, the number of people diagnosed with diabetes mellitus has increased by more than 1 million people. At the same time, the overall prevalence of the disease is 2-3 times higher, which indicates the rapid spread of the disease and the urgency of the problem [1].

Diabetes mellitus is a pathological change in metabolic processes with a high risk of complications. In diabetes mellitus, the connection between the protein and mineral components of the bone structure is disrupted, tissue nutrition worsens, which leads to a slowdown in their repair and a decrease in density [2,3].

Maintaining the normal functioning of bone and muscle tissues, among other factors, is carried out by neurohumoral regulation, therefore, excessive or insufficient concentration of one or another hormone can lead to disruption of the metabolism of connective tissues and, as a consequence, their degradation [5,6,7].

Thus, arthropathies are a statistically frequent complication of diabetes mellitus: according to a number of authors, 58% of patients with type 1 diabetes mellitus and 24% of patients with type 2 diabetes mellitus were diagnosed with this complication [4].
Considering the above problems, it is obvious that it is necessary to study the qualitative parameters of bone tissue in persons suffering from diabetes mellitus.

In experimental studies conducted on laboratory animals with insulin deficiency, the results of histomorphic analysis demonstrate a decrease in the rate of bone structure formation [8,9,10]. Moreover, in these studies, a tendency towards a decrease in the length of the bony trabeculae, as well as the periosteal and endocortical surfaces of the cortical plate, was found; a decrease in the number of osteoblasts, a violation of their function and an increase in the rate of apoptosis were noted [11,12,13].

It has been shown that diabetes mellitus is a predisposing factor for the development of degenerative periodontal diseases leading to a weakening of the periodontal joint [17]. In patients with type II diabetes mellitus, the main factors of inflammatory diseases of the alveolar process are microangiopathies and acidosis, caused by a high concentration of glucose in the blood [16].

Insulin deficiency causes two significant problems: a decrease in the synthesis of collagen and alkaline phosphatase - compounds produced by osteoblasts, as well as a violation of calcium adsorption by the microvilli of the small intestine. Hypocalcemia stimulates the production of a hormone, which leads to resorption and thinning of the compact bone substance.

Thus, in diabetes mellitus, metabolic processes in the bone tissue are disturbed, and defects in the biomechanical properties of the bone structure develop, predisposing to its physical damage.

The mechanisms that presumably worsen the state of bone tissue in patients with diabetes mellitus include hyperglycemia and microangiopathy [15].

The authors note that pathological changes in the structure of bone tissue are caused by insufficient insulin exposure and are not associated with complications of diabetes mellitus.

This means that the mechanisms of pathological changes in bone tissue are the same for the first and second types of diabetes mellitus.

In addition, this phenomenon is not directly related to diabetes mellitus and may precede its clinical manifestations.

Although the structure of the jaw bone tissue does not differ significantly in chemical composition and structure from other bone structures of the human skeleton, the processes of internal restructuring in it proceed faster.

The height of the alveolar ridge in a healthy person is maintained by a physiological balance between the formation and resorption of bone tissue.

Computed tomography is a modern method of medical examination of the human dentition, which allows you to obtain a three-dimensional model of teeth and jaws in high resolution. Computed tomography is a more informative method of analysis compared to two-dimensional radiography, which includes targeted X-rays and orthopantomogram. Computed tomography improves diagnostic accuracy due to improved imaging of tissue and organ differentiation through high-resolution cross-sectional images without stratification [6,14].

Methods. The complex study involved 94 patients who were divided into 2 groups. The first group included 44 people with diabetes mellitus, in the second, control group, there were 50 patients without endocrine pathologies.

The criteria for inclusion in the study were: age from 25 years, a history of type I or II diabetes mellitus, no dentition defects or the presence of small (no 1 to 3 teeth) and medium (no 4 to 6 teeth) in length of defects.

The criteria for not being included in the study were: the presence of concomitant endocrine pathology, in addition to diabetes mellitus, general diseases in the stage of decompensation, the presence of oncological diseases, as well as the presence of the following dental diseases: pathological abrasion of teeth, large defects in the dentition, periodontitis.

The exclusion criterion was the refusal of patients to perform the proposed studies.

The average age of the subjects was 62.7 ± 1.8 years, excluding gender differences.

The examination was carried out on a Gendex-GXCB-500 dental tomograph using the icat vision software. The optical density on the dental tomogram was assessed using a density window with a side of 3 mm. Measurements in the studied groups were carried out in the interdental partitions of the existing teeth of the upper jaw at the levels of the middle and tops of their roots, as well as the upper edges of the alveoli. The average density value was automatically calculated by the program. The density was estimated in Hounsfield's arbitrary units. Measures of central trend and data dispersion were calculated using descriptive statistics methods; quantitative parameters depending on the type of distribution are presented as mean value (M) and standard deviation (SD), or when estimated using nonparametric statistics in the form of median (X_{med}) and interquartile range QR in the range (LQ 25%÷UQ75%). The analysis of the correspondence of the type of feature distribution to the law of normal distribution was carried out using the Shapiro-Wilk test; The critical level of significance of differences in testing statistical hypotheses was taken as $p < 0.05$. To analyze the differences between the subgroups identified by qualitative clinical and diagnostic features, the nonparametric Mann-Whitney method was used. When evaluating the values of the Student's criterion, the Bonferroni correction coefficient was used. Statistical processing of the data obtained was carried out using the Statistica 10 software, StatSoft, lic. Identification number AGAR207F394525FA-6.

Results: graphs 1-3 show that the most pronounced changes in the density of the bone structure were found in the area of the neck of the teeth of the upper jaw. Changes in bone density in the region of the central part of the roots of the teeth are less pronounced. In the area of the tops of a number of tooth roots, an increase in bone density is observed in patients with diabetes mellitus.
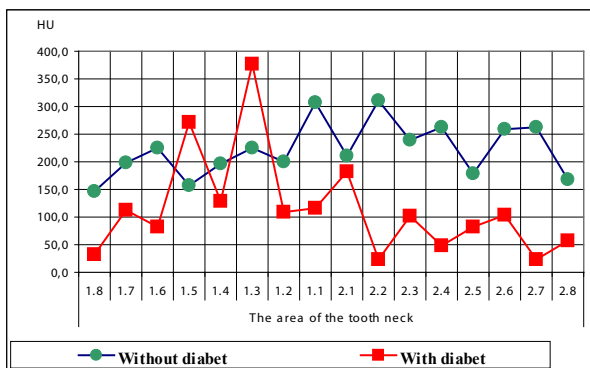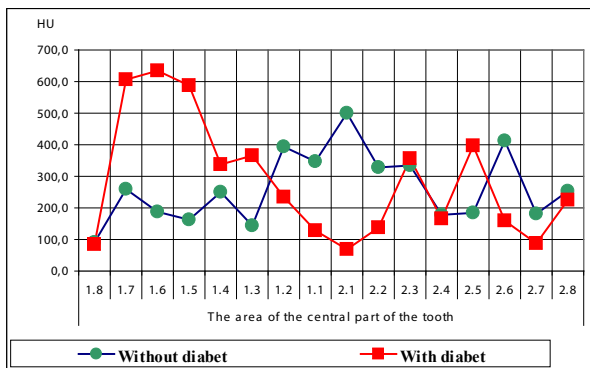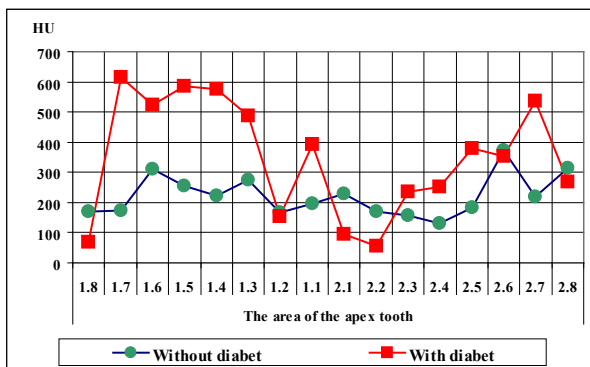
Figure 1-3. Comparative characteristics of the bone density of the upper and lower jaws according to the Gaussian density in Hounsfield units

A comparative analysis of the studied values revealed significant differences in the Gaussian density in the group of patients with diabetes mellitus due to a decrease in bone density.

Table 1. *Characteristics of the parametric data of the bone density of the upper jaw apex*

№ of tooth	M±SD	m	M±SD	m	t	P
	Patients without diabetes		**Patients with diabetes mellitus**			
1.8	235,2±107,3	87,4	166,7±47,7	32,9	**1,626**	**0,0492**
1.7	193,1±124,6	103,2	479,3±362,1	286,1	**-3,807**	**0,0000**
1.6	284,0±163,8	140,7	418,7±320,1	250,8	**-1,517**	**0,0223**
1.5	302,0±158,6	134,3	566,7±294,9	232,1	**-3,426**	**0,0184**
1.4	252,1±138,5	116,1	449,4±348,9	299,9	**-2,427**	**0,0007**
1.3	255,3±143,1	124,2	395,6±345,3	288,1	**-2,067**	**0,0001**
1.2	187,3±127,3	102,1	238,3±249,0	152,0	**-0,932**	**0,0027**
1.1	218,5±133,0	108,5	291,3±283,5	221,8	**-1,230**	**0,0006**
2.1	227,1±146,2	124,7	196,6±195,9	137,1	0,540	0,2075
2.2	239,9±191,5	145,7	151,2±75,8	51,4	**1,357**	**0,0095**
2.3	270,9±120,8	98,9	306,3±161,8	129,1	-0,850	0,1638
2.4	194,1±104,2	85,1	305,7±170,6	131,0	**-2,517**	**0,0397**
2.5	260,6±111,1	87,1	378,1±290,6	208,7	**-1,926**	**0,0001**
2.6	358,2±229,9	196,2	411,8±269,1	200,3	-0,580	0,4961
2.7	223,7±127,2	101,3	307,9±258,0	210,7	**-1,320**	**0,0066**
2.8	238,9±181,0	148,7	292,5±144,5	129,8	-0,653	0,6504

Note: Values at P <0.05 are highlighted in red

Table 2. *Characteristics of the parametric data of the bone density of the upper jaw in the region of the central part of the tooth root*

№ of tooth	M±SD	m	M±SD	m	t	P
	Patients without diabetes		**Patients with diabetes mellitus**			
1.8	237,0±95,1	68,8	133,6±40,4	30,8	**2,781**	**0,0411**
1.7	308,6±171,5	134,2	333,7±361,1	289,2	**-0,281**	**0,0058**
1.6	434,1±247,0	156,5	329,3±339,4	295,0	0,851	0,2688
1.5	302,8±106,9	87,2	506,6±282,3	228,4	**-3,315**	**0,0002**
1.4	447,4±184,1	148,3	364,8±211,3	163,5	0,987	0,5651
1.3	327,7±124,0	95,2	309,3±291,9	229,0	**0,317**	**0,0001**
1.2	434,0±222,2	189,0	189,5±193,5	145,8	3,203	0,6912
1.1	363,0±244,2	200,1	210,7±298,3	217,1	1,709	0,3630
2.1	473,6±256,1	227,1	181,1±329,1	193,5	2,982	0,2760

2.2	385,5±210,5	172,9	174,4±106,8	89,1	**2,912**	**0,0480**
2.3	475,4±265,8	188,7	314,0±242,2	209,5	2,029	0,4072
2.4	354,5±133,7	103,1	237,9±179,5	137,3	2,228	0,2124
2.5	470,4±224,4	193,8	304,0±244,2	195,8	0,649	0,1660
2.6	254,8±115,9	96,4	227,4±195,3	135,2	2,834	0,7479
2.7	304,5±170,4	143,9	132,4±54,8	44,8	2,712	0,0669
2.8	237,0±95,1	68,8	264,0±223,7	172,4	0,437	0,3879

Note: Values at P <0.05 are highlighted in red

Table 3. Characteristics of the parametric data of the bone density of the upper jaw in the area of the tooth neck

№ of tooth	M±SD	m	M±SD	m	t	P
	Patients without diabetes		**Patients with diabetes mellitus**			
1.8	318,5±132,9	89,5	66,9±33,5	23,8	**5,244**	**0,0010**
1.7	349,7±177,2	140,8	129,7±72,0	56,8	**2,978**	**0,0490**
1.6	400,2±281,6	200,3	176,2±144,1	101,8	1,733	0,1989
1.5	315,3±106,7	85,2	250,3±149,2	125,1	1,370	0,2010
1.4	433,5±184,1	143,3	145,2±67,6	53,4	**3,753**	**0,0339**
1.3	350,5±144,2	121,5	174,9±179,4	154,3	3,323	0,3250
1.2	391,5±163,7	131,7	156,0±166,3	98,2	4,077	0,8640
1.1	435,8±220,7	174,9	148,5±152,3	92,2	3,896	0,2350
2.1	430,6±235,4	134,7	130,9±107,1	93,0	5,472	0,4783
2.2	486,7±197,9	172,0	98,3±79,5	53,6	**5,748**	**0,0105**
2.3	426,4±463,7	245,7	129,4±118,5	85,5	**3,655**	**0,0260**
2.4	488,7±333,3	192,7	115,5±76,0	49,6	**5,228**	**0,0077**
2.5	389,5±236,8	146,7	173,8±174,9	111,9	3,018	0,5800
2.6	423,3±165,3	134,1	144,7±109,2	80,1	4,780	0,2184
2.7	281,2±195,6	153,8	101,0±59,6	37,3	**2,217**	**0,0144**
2.8	345,1±126,9	96,9	93,3±41,6	29,2	**5,081**	0,0113

Note: Values at P <0.05 are highlighted in red

Nonparametric analysis revealed a range of differences taking into account the value of the median and interquartile range (QR). So, when assessing the noted values of the data characterizing the significance of the differences in the upper jaw:

Upper jaw without NTG:

Tooth apex - 1.8 - Xmed =268.0 by QR (130.5÷302.0); **1.7** - Xmed =143.0 by QR (90.0÷263.0); **1.6** - Xmed =266.0 by QR (124.0÷436.0); **1.5** - Xmed =291.0 by QR (167.0÷421.0); **1.4** - Xmed =224.0 by QR (145.0÷366.0); **1.3** - Xmed =222.5 by QR (118.5÷392.0); **1.2** - Xmed =155.0 by QR (100.0÷267.0); **1.1** - Xmed

=243.5 by QR (86.5÷283.0); **2.2** - Xmed =165.5 by QR (115.0÷285.5); **2.4** - Xmed =167.5 by QR (127.0÷257.5); **2.5** - Xmed =257.0 by QR (173.0÷356.5); **2.7** - Xmed =209.0 by QR (109.0÷329.0);

Central part of upper jaw tooth root **-1.8** - Xmed = 229.0 by QR (177.0÷266.5); **1.7** - Xmed =260.5 by QR (152.0÷412.0); **1.5** - Xmed =316.0 by QR (222.0÷385.0); **1.3** - Xmed =301.0 by QR (264.0÷407.5); **2.2** - Xmed =365.5 by QR (213.0÷541.0);

Tooth neck Area- **1.8** - Xmed = 299.0 by QR (234.0÷380.0); **1.7** - Xmed = 308.5 by QR (245.0÷444.0); **1.4** - Xmed =421.0 by QR (329.0÷526.0); **2.2** - Xmed =504.0 by QR (321.0÷631.0); **2.3** - Xmed =293.0 by QR (221.0÷461.0); **2.4** - Xmed =461.0 by QR (326.0÷589.0); **2.7** - Xmed =229.0 by QR (98.0÷361.0); **2.8** - Xmed =309.0 by QR (278.0÷445.0);

Upper jaw with NTG:

Tooth apex -1.8 - Xmed =168.0 by QR (141.0÷211.0); **1.7** - Xmed =432.4 by QR (187.0÷802.0); **1.6** - Xmed =419.0 by QR (117.3÷641.0); **1.5** - Xmed =595.0 by QR (314.0÷901.0); **1.4** - Xmed =402.5 by QR (123.5÷698.0); **1.3** - Xmed =208.5 by QR (152.0÷640.0); **1.2** - Xmed =166.0 by QR (98.0÷253.0); **1.1** - Xmed =169.5.0 by QR (83.0÷475.0); **2.2** - Xmed =148.0 by QR (115.0÷172.0); **2.4** - Xmed =324.0 by QR (155.0÷407.0); **2.5** - Xmed =245.0 by QR (128.5÷507.5); **2.7** - Xmed =184.0 by QR (81.0÷617.0);

Central part of upper jaw tooth root -1.8 - Xmed = 142.0 by QR (88.0÷172.0); **1.7** - Xmed =190.0 by QR (47.0÷654.0); **1.5** - Xmed =498.0 by QR (238.0÷824.0); **1.3** - Xmed =206.0 by QR (77.0÷444.0); **2.2** - Xmed =198.0 by QR (86.0÷223.0);

Tooth neck Area- **1.8** - Xmed = 64.0 by QR (45.0÷77.0); **1.7** - Xmed =147.0 by QR (66.0÷179.0); **1.4** - Xmed =157.5 by QR (76.0÷205.0); **2.2** - Xmed =72.0 by QR (56.0÷79.0); **2.3** - Xmed =83.0 by QR (50.0÷151.0); **2.4** - Xmed =95.0 by QR (71.0÷120.0); **2.7.** - Xmed =92.5 by QR (84.0÷108.0); **2.8** - Xmed =93.0 by QR (63.0÷120.0);

The presented data indicate significant changes in bone density, both according to the results of parametric and non-parametric analysis, in diabetes mellitus in comparison with the control group and the characteristics of the teeth.

Discussion and conclusions: during the comparative analysis of the diabetic and control groups, it was found that in patients with diabetes mellitus there is a decrease in bone density in the area of the necks of the teeth, the least pronounced changes were observed in the area of the middle third of the roots of the teeth. Subtle changes (including compaction of bone tissue) were found in the area of the tops of the teeth. These results are similar to the conclusions put forward by domestic authors (Bondarenko N.N., Balakhontseva E.V., 2012, Nikolayuk V.I., Kabanova A.A., Karpenko E.A., 2015, Chuev V.P. and coauthors, 2017, Khaibullina R.R. et al., 2018).

It is also worth noting that in the group of people with diabetes mellitus, the bone density indicators of the upper jaw range from 151.2 to 566.7 conventional units. in the apical region of the teeth, from 132.4 to 506.6 conventional units. in the area of the central part of the roots and from 29.2 to 154.3 conventional units. in the area of the necks of the teeth. A direct dependence of changes in density in the area of the necks of all teeth, especially in the area of molars and incisors, was revealed, which is explained by the deterioration of the trophic function of the periodontium, inflammatory processes and a slowdown in the repair of the bone structure. Changes in the area of the tops of the teeth are less pronounced, while in the area of the lateral group of teeth, an inverse relationship is observed: here the indicators of bone density in persons with diabetes mellitus are higher than in the first group, which can be explained by the included reparative processes and the nature of the blood supply of this area.

Conclusions:

1. Computed tomography enables the dentoalveolar segment to quantitatively and qualitatively assess optical density, and is also an effective method for assessing the state of bone tissue in diabetes mellitus.

2. During the analysis of the bone density of the alveolar process of the upper jaw, it was revealed that the changes in the bone structure in diabetes mellitus are symmetrical.

3. Patients with type I and II diabetes mellitus showed a significant decrease in the density of the bone structure of the upper jaw in the cervical region of all groups of teeth, however, the pathologies of bone tissue development in the apical and central parts of the roots of the teeth are less pronounced.

4. An increase in bone density is observed in the central part of the roots of molars and premolars, as well as in the area of the apex of the teeth of the upper jaw in patients with diabetes mellitus.

5. Summing up the results of the study, it can be argued that the change in density is a direct criterion for assessing the state of the bone tissue of the jaws and, as a consequence, the most important sign that allows early diagnosis and prognosis of periodontal tissue diseases in patients with diabetes.

Disclosures. All authors have not disclosed potential conflicts of interest regarding the content of this paper.

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内镜经乳头状介入术治疗阻塞性黄疸的失败回顾性分析
RETROSPECTIVE ANALYSIS OF FAILURES OF ENDOSCOPIC TRANSPAPILLARY INTERVENTIONS IN OBSTRUCTIVE JAUNDICE OF TUMOR GENESIS

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抽象。 现代肝病学中最难解决的问题之一是治疗患有肿瘤性梗阻性黄疸的患者。 在这项工作中，我们对肿瘤起源的阻塞性黄疸患者的内镜经乳头内介入治疗的结果进行了回顾性分析。 结论是无法进行内窥镜经乳头状介入治疗的原因，以及这些措施的有效性。

关键词：内窥镜检查，微创手术，胰十二指肠癌，经乳头状介入，梗阻性黄疸。

Abstract. *The problem of treating patients with obstructive jaundice of tumor genesis is one of the most difficult in modern hepatology. In this work, we performed a retrospective analysis of the results of endoscopic transpapillary interventions in patients with obstructive jaundice of tumor origin. Conclusions were made about the reasons for the impossibility of performing endoscopic transpapillary interventions, as well as the effectiveness of these actions.*

Keywords*: endoscopy, minimally invasive surgery, pancreatoduodenal cancer, transpapillary interventions, obstructive jaundice.*

The problem of treating patients with obstructive jaundice is one of the most difficult in modern hepatology, and the death rate from cancer of the pancreatoduodenal zone over the past 30 years has increased 10-12 times (Sedov, A.P. 2000). This is due to the fact that in most patients, at the time of treatment, an unresectable and potentially incurable tumor is found, prolonging life and improving its quality in this category of patients is an important part of the treatment of the disease (Fainshtein, I.A. et all., 2009). In 90% of patients, cancer of the pancreatoduodenal zone is complicated by obstructive jaundice (Malyarchuk, V.I. et all.,

2004, 2006, Patyutko, Yu.I et all., 2004, 2007).

Currently, the main method of decompression of the biliary tree is endoscopic transpapillary drainage of the bile ducts in tumors of the biliopancreatoduodenal region complicated by obstructive jaundice. Thus, in a prospective study of the quality of life of patients after endoscopic endobiliary stenting (with plastic stents), a significant improvement in the quality of life of patients with a successful stent placement was shown (Abraham, N. S. Et all., 2002; Karpachev A.A. 2013).

For more than 30 years in our country, transpapillary endoscopic interventions have been used in clinical practice, of which a whole range of complex and laborious operations has been known and used for more than 20 years. Two factors are noteworthy (A. S. Balalykin et all., 2007): 1. The failure rate does not fall below 10-15%; 2. Even in large institutions in Russia, the entire arsenal of modern and expensive operations is not used. Performing transpapillary interventions is accompanied by a number of consequences that can be classified as difficulties (impossibility of selective cannulation of the common bile duct and contrasting of the biliary tract due to complex anatomical and topographic changes in the area of the large duodenal papilla), failure (inability to perform transpapillary intervention or its completion at the stage cannulation or contrasting, which is associated with anatomical abnormalities in this area) and complications (worsening of the patient's condition due to the direct effect of the operation) (Bluvshtein G.A., et all 2007).

The purpose of this work is to analyze the failures of endoscopic transpapillary interventions in cancer of the pancreatoduodenal zone.

The work carried out a retrospective analysis of the results of endoscopic transpapillary interventions in 386 (100%) patients with obstructive jaundice of tumor genesis, of which pancreatic head cancer was observed in 177 (45.85%), cancer of the large duodenal papilla in 145 (37.56%), cancer of the distal common bile duct in 64 (16.59%) patients.

Starting to analyze the failures of endoscopic transpapillary interventions, it should be noted that they were performed in all 66 patients who underwent radical interventions.

Out of 66 patients, 17 (25.8%) did not require decompression, since these patients either had a normal bilirubin level or hyperbilirubinemia did not exceed 150 µmol / L, which made it possible to perform radical surgery. In cancer of the pancreatic head, decompression interventions were not required in 8 (32%) patients, in patients with cancer of the major duodenal papilla in 9 (25.7%) patients, in cancer of the distal common bile duct, they were performed in all cases.

A summary table of failures of endoscopic surgery and subsequent decompression methods is presented below (Table 1).

Table 1.

Reasons for the failure of endoscopic interventions in patients with cancer of the pancreatoduodenal zone

Reason for failure	The nature of the surgical intervention			
	Pancreatic head cancer			
	Resection interventions	**Biliodigestive anastomoses**	**Percutaneous transhepatic cholangiostomy**	**Other**
Failure to cannulate the terminal section of the common bile duct	5	17	16	
Resection B-2			2	
Duodenal stenosis	1	4	7	4
Diverticulum of the greater duodenal papilla		1	1	
Lack of visualization of the large duodenal papilla		1	1	
Retroperitoneal cannulation			2	
Duodenal papilla cancer				
Failure to cannulate the terminal section of the common bile duct	3	2		4*
Distal common bile duct cancer				
Failure to cannulate the terminal section of the common bile duct	3	3	6	
Lack of visualization of the large duodenal papilla				
Total	12	28	36	8

* – RF patent for invention № 22978079 (n = 3) and endoscopic papillectomy (n=1)

Significant technical difficulties in performing endoscopic transpapillary interventions arose when the tumor stricture was localized in the distal common bile duct. We agree with the opinion of Maada A.S. (2002) that tumors of the pancreatic head are the most difficult for drainage, especially in combination with duodenal stenosis (Maady, AS et all).

If it was impossible to cannulate and perform stenting, we used the original method of decompression and palliative treatment for a tumor of the head of the pancreas (RF patent 2327425 C1), when endoscopic intervention was unsuccessful, percutaneous transhepatic microcholangiostomy was performed in these patients to decompress the biliary tree.

In all cases, satisfactory functioning of the fistulogastric fistula was noted, which was monitored by dynamic endoscopic examination. The life expectancy of patients was 12 and 5.5 months.

In 2 cases, with endoscopic retrograde cholangiopancreatography, the contrast was noted outside the common bile duct. In this situation, the endoscopic intervention was stopped, and the patients underwent percutaneous transhepatic decompression methods (percutaneous transhepatic microcholangiostomy).

In our study, as in the studies of other authors, good results of endoscopic transpapillary interventions were observed in tumors of the major duodenal papilla.

The main reasons for the failure of endoscopic drainage in cancer of the major duodenal papilla were difficulties in selective cannulation of the common bile duct due to pronounced tumor changes in the major duodenal papilla, disrupting its anatomical landmarks and the anatomy of the distal common bile duct. it was not possible to perform classical papillotomy or endoscopic suprapapillary choledochoduodenostomy due to disturbed anatomical landmarks and the danger of retroduodenal perforation. We used the original method of endoscopic papillosphincterotomy developed by us (RF patent № 2297807.).

The disadvantages of the above-described classical methods are manifested in the fact that in some cases the correct cannulation of the large duodenal papilla may be difficult due to a widespread tumor process that violates anatomical landmarks. When performing suprapapillary choledochoduodenostomy with a needle electrode, there is a risk of retroduodenal perforation with the development of retroperitoneal phlegmon due to injury to the posterior wall of the common bile duct due to the lack of visual control over the position of the distal end of the needle.

With the known method of atypical papillotomy, the latter is carried out with a needle electrode by movements in the direction from the mouth of the large duodenal papilla to the base with a strictly layer-by-layer dissection of the tissues of the latter by diathermic current. The basis for the successful performance of papillotomy with this method is a clear visualization of the dissected layers of the anterior wall of the greater duodenal papilla.

The disadvantages of this method are associated with the complexity of this method in case of tumor lesion of the major duodenal papilla, since this violates the usual anatomical signs of various layers of the anterior wall of the major duodenal papilla due to unpredictable tumor invasion. In this case, there is a danger of damage to the mouth of the Wirsung duct with the development of pancreatonecrosis or injury to the posterior wall of the greater duodenal papilla, which leads to retroperitoneal perforation of the duodenum.

The essence of our proposed method is that after performing a percutaneous transhepatic cholangiostomy with a decompressive purpose, a 6 CH ureteral stent

with a conductor located in its lumen is passed through the drainage canal into the common bile duct. The stent is passed through the common bile duct through the large duodenal papilla into the duodenum, where a duodenoscope with a needle papillotome located in the instrumental canal has already been inserted. After visualization of the mouth of the large duodenal papilla, the latter is dissected layer by layer on the stent with a needle papillotome. If necessary, the resulting hole is expanded with a standard papillotome.

The method makes it possible to carry out endoscopic papillotomy in case of impossibility of papillotomy by typical or atypical methods with tumor lesion of the nipple due to a violation of anatomical relationships.

Finding a rigid ureteral catheter in the duodenal papilla protects the duodenum from possible retroduodenal perforation during papillotomy and Wirsung duct from distant effects of diathermic currents.

Other reasons for the failure of endoscopic interventions were the anatomical features of the duodenum in the form of a state after resection of the stomach according to Billroth II, as well as duodenal stenosis. Juxtapapillary diverticula in our studies were found only in 2 cases with pancreatic head cancer were an obstacle to endoscopic transpapillary intervention.

Duodenal stenosis, which prevents duodenoscopy in our observations, was observed in 16 patients, all of them had cancer of the head of the pancreas.

Another reason for the failure of endoscopic decompression may be the failure of cannulation of the distal common bile duct due to the pronounced tortuous course of the tumor stricture of the terminal common bile duct.

Thus, in diagnosed cancer of the pancreatoduodenal zone, the main methods of decompression are traditional surgical methods, including external methods of bile diversion and biliodigestive anastomoses, as well as minimally invasive antegrade and retrograde interventions. We believe that endoscopic transpapillary interventions are currently the main method for diagnosing cancer of the pancreatoduodenal zone, as well as decompressive intervention for the relief of obstructive jaundice. In addition, preliminary endoscopic decompression before radical intervention reduces the number of postoperative complications and mortality.

Unfortunately, they cannot be performed in 100% of patients due to certain reasons. Our observations showed that endoscopic transpapillary interventions were effective in 54.5% before radical intervention, in 19.7% other decompressive interventions were performed (percutaneous transhepatic cholangiostomy in 10 (15.1%) patients, video laparascopic cholecystostomy in 2 (3%) of patients, biliodigestive anastomoses in 1 (1.5%)), in 25.8%, no decompression was required.

Analyzing our own experience of failures of endoscopic transpapillary interventions, it can be concluded that in cancer of the pancreatoduodenal zone, the main reason for the impossibility of their implementation was

the failure of the cannulation of the distal common bile duct, which, according to our observations, occurred in 59 patients (70.2%), mainly was associated with tumor obstruction of the distal common bile duct, which made it difficult to guide the guide past the tumor stricture and subsequent stenting. In such cases, in order to decompress the biliary tree, percutaneous transhepatic methods of external bile diversion were performed in 36 patients (42.8%). In 2 cases, an original method for the formation of a biliodigestive anastomosis was used (RF patent 2327425 C1), which made it possible to provide duodenal passage of bile.

Other reasons for the failure of endoscopic interventions were the anatomical features of the duodenum in the form of a state after resection of the stomach according to Billroth II, as well as duodenal stenosis. Juxtapapillary diverticula in our studies only in 2 cases with pancreatic head cancer were an obstacle to endoscopic transpapillary interventions.

Duodenal stenosis, which prevents duodenoscopy in our observations, was observed in 16 patients with pancreatic head cancer.

The main reasons for the failures of endoscopic drainage in cancer of the major duodenal papilla were the difficulties of selective cannulation of the common bile duct due to pronounced tumor changes in the major duodenal papilla, disrupting its anatomical landmarks and the anatomy of the distal common bile duct, in such cases we used the original method of endoscopic papillosphincterotomy developed by us (for invention № 2297807.).

颌面异常定量评估方法在确定正畸治疗效果中的应用
APPLICATION OF THE METHOD OF QUANTITATIVE ASSESSMENT OF MAXILLOFACIAL ANOMALIES PAMORF TO DETERMINE THE EFFECTIVENESS OF ORTHODONTIC TREATMENT

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抽象。 文章R.A. 法德耶娃（A.N.） 拉尼娜（P.V. Lee介绍了牙颌颌面异常PAMORF定量评估方法的实际应用,这使得可以定量评估其体征,同时考虑了医生和患者的评估,并在此基础上选择治疗策略 ,并根据治疗结束时症状严重程度的变化,判断其有效性。
关键词：牙颌面异常的定量评估方法,疾病的严重程度,美学,形态,咬合,功能,吸收,牙齿闭合位置,保留,牙本质,功能性疾病,心理学,治疗效果, PAMORF, AMORF, PAOF。
Abstract. *In the article "Application of the PAMORF method of quantitative assessment of dento-maxillofacial anomalies to determine the effectiveness of*

orthodontic treatment" authors R.A. Fadeeva, A.N. Lanina, P.V. Lee presented a practical application of the method of quantitative assessment of dento-maxillofacial anomalies PAMORF, which makes it possible to characterize their signs quantitatively, taking into account the assessment of both the doctor and the patient, and based on this, choose a treatment tactic, and based on the change in the severity of signs at the end of treatment, judge its effectiveness.

Keywords: *method of quantitative assessment of dento-maxillofacial anomalies, severity of disorders, aesthetics, morphology, occlusion, function, resorption, close position of teeth, retention, adentia, functional disorders, psychology, treatment effectiveness, PAMORF, AMORF, PAOF.*

Introduction

Dentofacial anomalies (DFA) are characterized by morphological, aesthetic, occlusal signs, in a number of cases - resorption of periodontal bone tissue, which should be considered in the sagittal, vertical and transversal directions, as well as functional disorders, tight position of teeth, their retention, root resorption and adentia. The choice of treatment tactics depends on the severity of these signs and the absence of a directly proportional relationship between them, as a result of which the use of methods for quantifying DFA is justified [10, 11]. The patient's subjective assessment of DFA signs in some cases may differ significantly from the doctor's assessment [4], and therefore, along with the physician's quantitative assessment of the DFA signs, it is advisable to take into account the patient's own assessment of the internal DFA pattern in order to choose a treatment strategy and evaluate its result.

For this purpose, we have proposed and tested on more than 1000 patients with DFA Quantitative assessment method AMORF ("A" - Aesthetics, "M" - Morphology, "O" - Occlusion, "R" - Resorption, "F" - Function), which allows you to identify 3 degrees of severity of aesthetic, morphological, occlusive disorders, as well as assess the resorption of periodontal bone tissue in the sagittal, vertical, transversal directions, 3 degrees of functional disorders, close position of teeth, their retention, root resorption, 2 degrees of adentia [1, 5, 6, 7, 8, 9], as well as the PAOF Quantification Method ("P" - Psychology, "A" - Aesthetics, "O" - Occlusion, "F" - Function), which allows quantifying DFA traits with the patient's point of view [2, 3, 4]. On the basis of these methods, a method for a complete quantitative assessment of PAMORF was created ("P" - Psychology, "A" - Aesthetics, "M" - Morphology, "O" - Occlusion, "R" - Resorption, "F" - Function), in according to which it is possible to assess the signs of DFA jointly by the doctor and the patient.

Practical use

The degree of severity of each DFA sign is determined by the physician in accordance with the AMORF method of quantitative assessment and enters the nu-

merical values in the corresponding table (Table 1). Further, the total numerical indicators are determined by blocks before and after treatment. The proposed method makes it possible to assess morphological, aesthetic, occlusal features, resorption of periodontal bone tissue in the sagittal, vertical and sagittal directions, as well as to assess the close position of teeth, their retention, root resorption and adentia.

For a quantitative assessment of the internal picture of DFA PAOF, the patient is asked to answer the questions of the questionnaire, which are grouped into four blocks: psychological, aesthetic, occlusive and functional before and after treatment (Table 2). The answer is given in the form of highlighting in any way, for example, by encircling one of the numbers in the table corresponding to a given statement, feeling, state. The assessment is carried out on a 4-point system. At the same time, the numbers next to each indicator indicate the quantitative assessment of the violations identified. The digital value "0" means the absence of violations for this indicator, the digital value "4" means the presence of the most pronounced changes in this indicator. Further, the identified violations are assessed. The scores for each of the four blocks of the questionnaire are summed up and characterize the quantitative assessment of signs.

The complete quantitative assessment of DFA, taking into account the patient's subjective assessment of PAMORF, is determined by summing the assessments of the doctor and the patient, while the indicators for the blocks "Aesthetics", "Occlusion", "Function" are integral, "Psychology" is assessed only by the patient, "Morphology", " Resorption ", as well as indicators of the close position of the teeth, their retention, edentulous and root resorption are assessed only by a doctor.

To determine the effectiveness of the treatment, taking into account the subjective assessment of the internal picture of DFA by the method of full quantitative assessment of PAMORF, the points before treatment are added - this is 100%, and the points after treatment. The numerical result is determined by making a proportion and is interpreted as follows: up to 25)% - "significant improvement, taking into account subjective assessment"; [25-45)% - "significantly improved taking into account the subjective assessment"; [45-65)% - "moderately improved, taking into account the subjective assessment"; [65-85)% - "minimally improved taking into account subjective assessment"; [85% and more - "not improved or worsened, taking into account the subjective assessment."

To demonstrate the application of the PAMORF Complete Quantification Method, we present an extract from the case histories.

Patient S., 36 years old (Fig. 1 a-c, 2 a-e), went to the clinic with complaints of difficulty in biting and chewing food, protrusion of the lower jaw. The diagnosis was made: mesial ratio of the dentition, lower prognathia, crossbite, protrusion of the upper and retrusion of the lower incisors, parafunction of the masticatory muscles, tooth loss 3.6, chronic generalized periodontitis, pronounced recessions

of the gingival margin in the area of teeth 3.1, 4.1. Table 1 presents a quantitative assessment of the DFA AMORF signs of patient S., from which it can be seen that the main disturbances were due to the violation of facial aesthetics, morphology and occlusion in the vertical and sagittal directions, as well as the tight position of the teeth and the function of the chewing-speech apparatus.

a   b   c
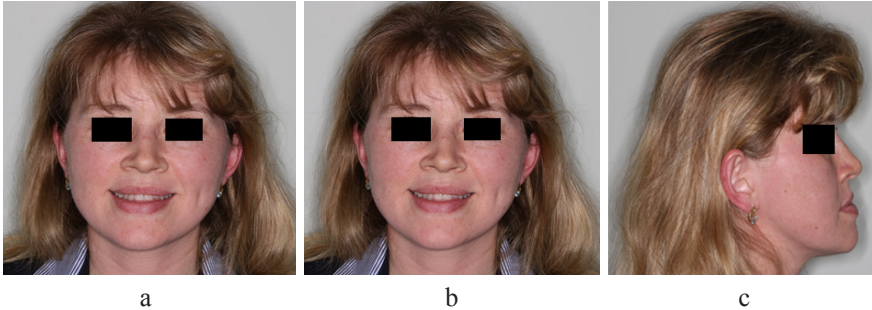
Figure: 1. Photos of patient S.'s face before treatment (a-c)

a   b   c   d   e
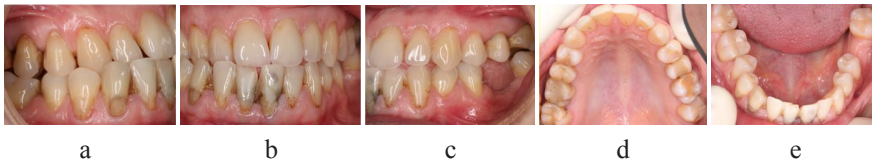
Figure: 2. Photos of patient S.'s dentition before treatment (a-e):
occlusion disorders of the 2nd degree in the sagittal, 1st degree - in the vertical and transversal directions are determined, the close position of the 1st degree teeth is determined

Table 1
Quantification of DFA signs of patient S., 36 years old,
before/after AMORF treatment

Direction	A	M	O	R	F
Sagittal	3/**2**	2/**1**	2/**0**	0/**0**	
Vertical	2/**2**	1/**1**	1/**0**	0/**1**	1/**0**
Transversal	1/**1**	1/**1**	1/**1**	0/**0**	
Attribute	*1st degree*		*2nd degree*		*3rd degree*
Tight position	+/**0**		-----		-----
Retention	-----		-----		-----
Root resorption	0/**0**		-----		-----
Adentia/excess space	-----		-----		

Based on the nature of the complaints, as well as the correspondence of a number of signs of 2 and 3 degrees (aesthetics, morphology), the patient was offered an etiotropic instrumental-surgical treatment plan with the use of reconstructive surgery, which would allow to correct DFA in the best way. However, despite her own rather high assessment of the aesthetic sign of DFA (3 points in table 2), the patient refused it, and therefore an alternative treatment plan was implemented, which included the use of a splitting splint on the lower jaw with simultaneous expansion of the upper jaw using a fixed screw apparatus with extra-bone fixation, tooth extraction 4.8, installation of a bracket system on the upper jaw, fixation of occlusal patches and a partial bracket system on the lower lateral teeth, their movement in the distal direction (on the right - with the help of an orthodontic microimplant), installation of braces -systems for the lower anterior teeth, their retraction, the creation of multiple occlusal contacts, the removal of the bracket system, the retention period, rational prosthetics. The main stages of orthodontic treatment are shown in Figures 3-7.

Table 2

Evaluation of the internal picture of DFA of patient S. PAOF
before/after treatment

A statement, feeling, or state	Absent	Weakly expressed	Moderately expressed	Clearly expressed	Expressed very strongly
Block 1 - Psychological attitude of the patient to the disease "P"					
1. Does this condition affect your well-being?	**0**	1			
2. Does this condition interfere with your communication with other people?	**0**	1			
3. Does this condition affect your performance?	0/**0**				
4. Does this condition affect self-confidence?		1/**1**			
Are you bothered by any of the following?	Block 2 - Disorders of facial aesthetics "A"				
1. Asymmetry	**0**	1			
2. Increase or decrease in face height	0/**0**				

A statement, feeling, or state	Absent	Weakly expressed	Moderately expressed	Clearly expressed	Expressed very strongly
3. Front or back position of the chin, upper or lower jaw, upper or lower lip		1		3	
4. Protruding or sunken nose	0/**0**				
5.Other (specify)	0/**0**				
Are you bothered by any of the following?	Block 3 - Occlusal violations "O"				
1. Close position of teeth	0/**0**				
2. Tremes (intervals) of the dentition	**0**	1			
3. Protrusionof the upper or lower incisors	0/**0**				
4. Retrusion of the upper or lower incisors	0/**0**				
Are you bothered by any of the following?	Block 4 - Functional violations "F"				
1. Food biting disorder	**0**	1			
2. Impaired chewing	**0**	1			
3. Swallowing disorder	0/**0**				
4.Disrupted mouth opening	0/**0**				
5.Nasal breathing disorder	0/**0**				
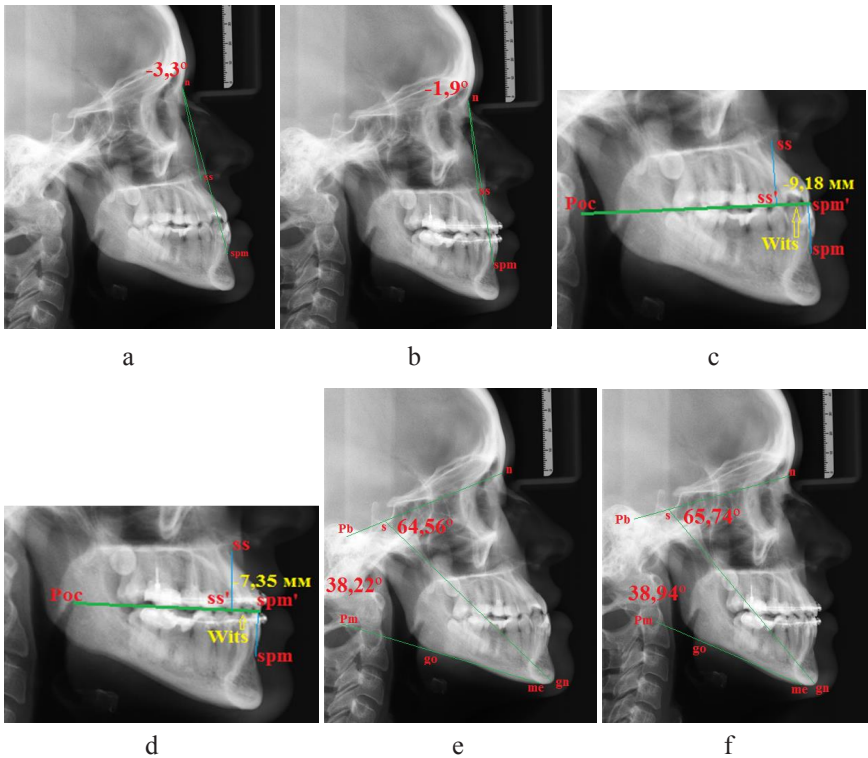
Figure: 3. Lateral TRG of the skull of patient S. before (a, c, e) and after (b, d, f) treatment: the values of the parameters ss-n-spm and Wits correspond to the 2nd degree of severity of morphological disorders in the sagittal direction before treatment (a, c), and 1 - at the end of it (b, d); the value of the n-s-gn parameter corresponds to grade 1 before treatment and normal - after its completion, Pm/Pb - grade 1 before and after treatment (e, f)

d   e   f
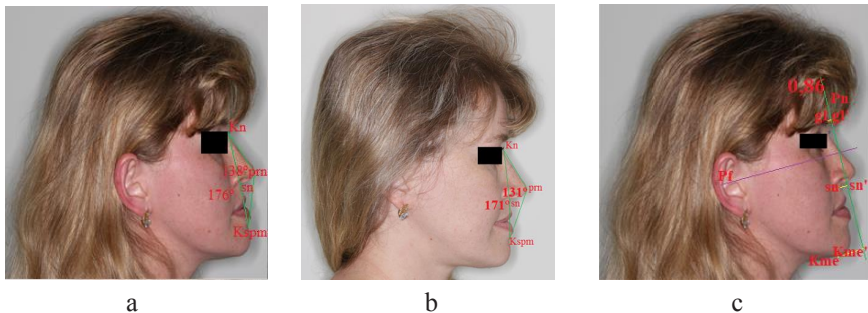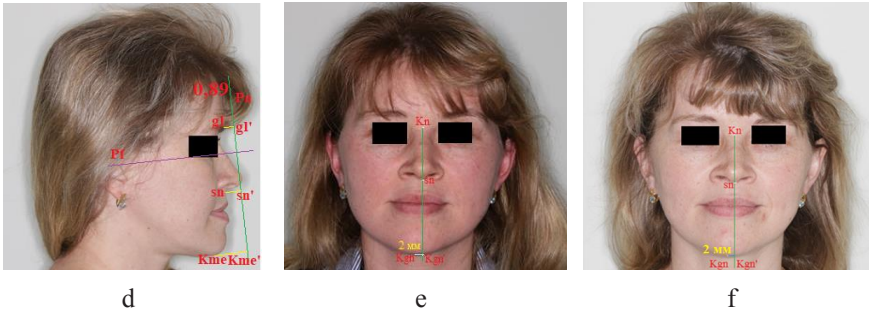
Figure: 4. *Photographs of patient S.'s face before (a, c, e) and after (b, d, f)
treatment: the value of the Kn-sn-Kspm parameter corresponds to 3 degrees of
severity of facial aesthetics disorders in the sagittal direction before treatment (a)
and 2 - after its completion, Kn-prn-Kspm - 2 degrees before and after treatment
(b); the value of the ratio gl'-sn /sn'-Kme (Pn) before treatment corresponds to
2 degrees before and after treatment (c, d); Kgn-Kgn '(Kn-sn) values before and
after treatment correspond to grade 1 before and after treatment (e, f)*

a   b   c   d

e   f   g   h
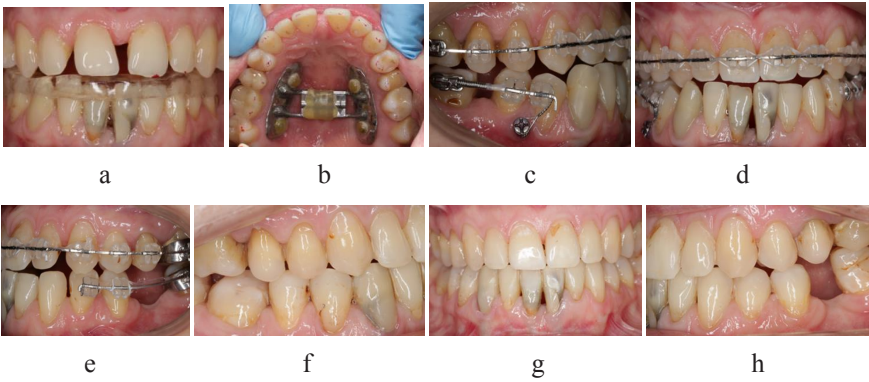
Fig. 5. *The dentition of patient S. at the stages of orthodontic treatment (a-h):
a muscle relaxation mouthguard is fixed on the lower jaw (a), on the upper jaw
- a screw apparatus with extra-bone fixation for fast palatal expansion, with
preliminary compactosteotomy (b); the ratio of the dentition of patient S. at the
stage of treatment (c-e): distal movement of the lateral teeth (d, e), on the right -
with support on the microimplant (c); the ratio of the dentition of patient S. upon
completion of orthodontic treatment (f-h): occlusal overlays are fixed on the
lower lateral teeth (f, h), observation by a periodontist and rational prosthetics
are recommended*

a   b
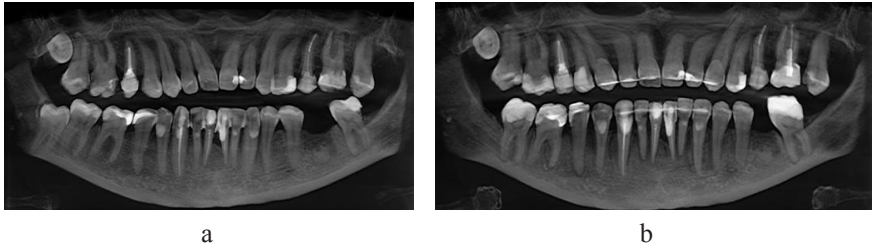
Figure: 6. *CBCT section of the jaws of patient S. before and after treatment (a, b)*

a   b   c
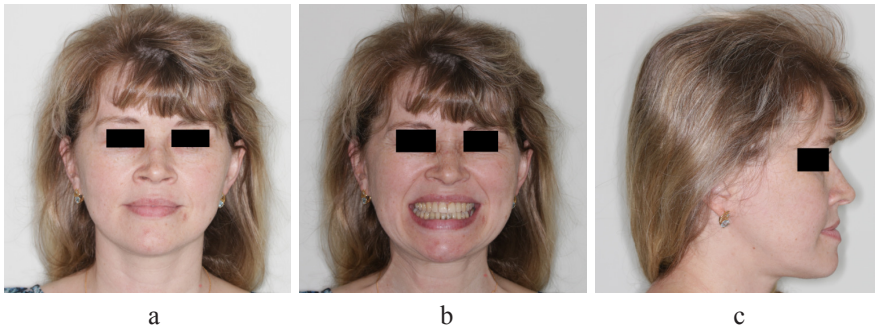
Figure: 7. *Photos of the patient S.'s face after orthodontic treatment (a-c)*

Determination of the effectiveness of the treatment given to patient S. (Table 1) according to the AMORF method of quantitative assessment:

A6M4O4R0F1+1 → A5M3O1R1F0+0

Before treatment: 16 — 100%

After treatment: 10 − 62,5%

The effectiveness of the treatment was interpreted as "moderately improved".

The dynamics of the internal picture of DFA of patient S. according to the PAOF quantitative assessment method (table 2) is as follows:

P3A4O1F2 → P1A1O0F0

Before treatment: 10 — 100%

After treatment: 2   —   20%

Thus, the dynamics of the internal picture of DFA is interpreted as "the subjective assessment is significantly improved".

The complete quantitative assessment of the DFA of patient S., taking into account the subjective assessment of PAMORF, is as follows:

P3A10M4O5R0F3+1 → P1A6M3O1R1F0+0:

Before treatment: 26 — 100%

After treatment: 12 -   46,15%,
which is interpreted as "moderate improvement based on subjective assessment."

Violations of occlusion, the functions of the chewing-speech apparatus, and the cramped position of the teeth were almost completely eliminated. On average, the severity of the aesthetic and morphological signs of DFA decreased by 1 point in each direction, but if the patient agreed to the proposed etiotropic instrumental-surgical treatment plan with the use of reconstructive surgery, these signs could be corrected to a greater extent. It should also be noted that the patient's own satisfaction with the treatment results was significantly higher than the doctor's assessment, and ultimately influenced the overall assessment of the outcome of the PAMORF alternative treatment plan.

Conclusions

1. The use of methods for quantitative assessment of DFA in clinical practice allows, based on the severity of certain signs, to understand its etiology and patho-genesis, on the basis of this, to choose a treatment tactics, and by the change in the severity of signs after treatment, to objectively judge its effectiveness.

2. In order to identify violations of facial aesthetics, morphology and function of the masticatory-speech apparatus, occlusion and position of teeth in patients with DFA, as well as to determine the patient's psychological attitude to existing disorders, it is very promising and informative to use the AMORF quantitative assessment method together with registration questionnaires for PAOF patients.

3. The joint DFA (doctor+patient) PAMORF assessment allows you to see how the proposed (implemented) treatment plan reflects the patient's complaints, as well as assess his satisfaction with the result achieved.

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心力衰竭时血液中的缺氧诱导因子和细胞因子
THE HYPOXIA-INDUCED FACTORS AND CYTOKINES IN BLOOD AT HEART FAILURE

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抽象。
目的: 根据缺血性心肌病 (ICMP) 的存在, 在冠心病 (CHD) 背景下确定慢性心力衰竭 (CHF) 患者血中缺氧诱导因子和细胞因子失衡的特征。 。
材料和方法。总共检查了47例有ICMP和无ICMP的心力衰竭和CHD (心绞痛功能 II-IV级) 患者 (分别为27和20个人)。对照组由14名年龄和性别分布可比的健康个体组成。血浆中HIF-1alpha, HIF-2alpha, 单核细胞趋化蛋白1 (MCP-1), 肿瘤坏死因子α (TNF-alpha), 干扰素-γ (IFN-γ) 和白介素10 (IL-10) 的浓度通过ELISA测定。
结果。已经显示, 在CHD背景下的CHF中, 无论是否存在ICMP, 血液中都存在过量的TNF-α, IFN-γ为零。在没有ICMP的CHD患者中, 正常IL-10水平下, ＭＣＰ-1的血浆浓度相对升高 (225,0 [182,0; 280,0] pg ／ ml, p = 0.047), 而在ICMP患者中与血液中IL-10水平升高的对照组值相当 (30,05 [24,75; 33,50] pg ／ ml, p = 0,026)。在患有ICMP的患者中, HIF-1alpha不足 (0.037 [0,020; 0,045] ng ／ ml, p= 0.0353) 和HIF-2alpha过量 (40,74±10,95%的患者为非零) 与没有ICMP的CHD患者中这些

分子的正常含量相比，检测到的这些值p ＝ 0,009）（分别为0,051 ［0,040； 0,138］ ng ／ ml和0%）。

结论。冠心病背景下，CHF时血液中HIF和细胞因子的含量取决于ICMP的存在。后者的特征在于免疫抑制，与过量的HIF-2和缺乏的HIF-1相关。

关键词：心力衰竭，缺血性心肌病，缺氧诱导因子，细胞因子。

Abstract.

The aim: to identify the features of the imbalance of hypoxia-induced factors and cytokines in the blood of patients with chronic heart failure (CHF) on the background of coronary heart disease (CHD), depending on the presence of ischemic cardiomyopathy (ICMP).

Materials and methods. *A total of 47 patients with heart failure and CHD (angina functional class II-IV), with and without ICMP (27 and 20 individuals, respectively) were examined. Control group consisted of 14 healthy individuals with comparable age and gender distribution. Plasma concentration of HIF-1alpha, HIF-2alpha, monocyte chemoattractant protein-1 (MCP-1), tumor necrosis factor alpha (TNF-alpha), interferon-gamma (IFN-gamma), and interleukin-10 (IL-10) was determined by ELISA.*

Results. *It has been shown that at CHF on the background of CHD, regardless of the presence of ICMP, there was an excess of TNF-alpha, with zero value of IFN-gamma, in the blood. In CHD patients without ICMP, plasma concentration of MCP-1 was relatively increased (225,0 [182,0; 280,0] pg/ml, p=0,047) at a normal level of IL-10, while in patients with ICMP it was comparable to the control group values with an increased level of IL-10 in the blood (30,05 [24,75; 33,50] pg/ml, p=0,026). In patients with ICMP, a deficiency of HIF-1alpha (0,037 [0,020; 0,045] ng/ml, p=0,0353) and an excess of HIF-2alpha (40,74±10,95% of patients had non-zero values, p=0,009) were detected, in comparison with the normal content of these molecules in CHD patients without ICMP (0,051 [0,040; 0,138] ng/ml and 0%, respectively).*

Conclusion. *The content of HIFs and cytokines in the blood at CHF on the background of CHD depends on the presence of ICMP. The latter is characterized by immunosuppression, associated with an excess of HIF-2 and a deficiency of HIF-1.*

Key words: *heart failure, ischemic cardiomyopathy, hypoxia-induced factors, cytokines.*

Introduction. Heart failure causes the development of circulatory hypoxia, which leads to the synthesis of hypoxia-induced factors (HIFs) in cells. The majority of literature sources contain information about the growing formation of HIF-1 under conditions of oxygen deficiency, which is able to activate the synthesis of pro-inflammatory cytokines [1, 2]. Therefore, the idea, that hypoxia initiates inflammation and stimulates immunocompetent cells, is formed. Meanwhile, the

balance between HIF-1 and HIF-2 has a significant impact on the state of the immune system. Thus, the accumulation of HIF-1 in myeloid cells promotes the synthesis of pro-inflammatory cytokines and suppresses the maturation of regulatory Foxp3^{+} T cells (Treg) with immunosuppressive function [3]. At the same time, in patients with chronic heart failure on the background of coronary heart disease, activation of the monocyte-macrophage system occurs not only due to hypoxia, but also due to atherogenesis. Hypoxia and atherosclerosis are the key factors in the development of coronary heart disease, which is associated with ischemic cardiomyopathy in some cases; however, the factors responsible for its initiation remain to be elucidated [4, 5]. Perhaps the basis of ICMP is a violation of the synthesis of HIFs and regulatory molecules of the immune system.

Objective: to identify the features of the imbalance of hypoxia-induced factors and cytokines in the blood of patients with chronic heart failure (CHF) on the background of coronary heart disease (CHD), depending on the presence of ischemic cardiomyopathy (ICMP).

Material and methods. The study case-control engaged 47 CHD patients with angina of effort functional class II-IV and circulatory inefficiency of predominantly II-IV functional classes according to NYHA. Patients with CHD were divided into 2 groups: 27 individuals, suffering from ICMP (age 54,12±4,30 years; left ventricular ejection fraction is ≤40%, acute myocardial infarction or revascularization, stenosis of the left main or proximal part of the left descending artery is ≥75% or stenosis of two or more epicardial vessels is ≥75% [6] and 20 individuals, without ICMP (age 5,60±3,92 years; left ventricular ejection fraction is >40%, acute myocardial infarction or revascularization, coronary stenosis of any site is ≥75%). The control group consisted of apparently healthy 14 individuals without any cardiovascular diseases. The concentration of HIF-1alpha, HIF-2alpha, monocyte chemoattractant protein-1 (MCP-1), tumor necrosis factor alpha (TNF-alpha), interferon-gamma (IFN-gamma), and interleukin-10 (IL-10) in peripheral blood plasma from the ulnar vein in patients of both study groups and healthy donors was determined by followed ELISA kits: «Human HIF-1alpha ELISA Kit», «Human HIF-2alpha ELISA Kit» («Cloud-Clone-Corp», USA), «MCP-1-ELISA-BEST», «alpha-TNF-ELISA-BEST», «IL-10-ELISA-BEST», «gamma-IFN-ELI-SA-BEST» («Vector-BEST», Novosibirsk).

The study conformed to the principles outlined in the Declaration of Helsinki and was carried out with the permission of the local ethics committee of Siberian State Medical University (protocol №5046 (28.11.2016)). All subjects gave written informed consent for the use of their data. The criteria for excluding patients from the study were age over 70 years, autoimmune diseases, an allergic process in the stage of exacerbation, a tumor process, hypoplastic and megaloblastic anemias, virus hepatitis, syphilis, HIV-infection, pre-surgery therapy with iron-

containing drugs, erythropoietin or immunosuppressive therapy, and the presence of acute infectious diseases less than 3 weeks before the surgery, as well as the patients refusal of study.

Statistical data analysis was performed using «Statistica 10.0» software. When statistically describing the quantitative criteria, the median, 25th and 75th percentiles were calculated. When statistically describing the qualitative criteria, sample rate was calculated. For the purpose of comparative analysis of sample data, Mann-Whitney test (for independent samples) was used. To compare the frequencies of occurrence of signs in the group, we used the Chi-square test with Yates correction for continuity. To assess the linear relationships between studied criteria, the Spearman rank correlation coefficient was calculated. The results of statistical analysis were considered significant at p<0,05.

Results and discussion. Our study revealed a high concentration of TNF-alpha in the blood of CHD patients, both suffering and not suffering from ICMP, which may be due to CHF. Hypoxia directly stimulates the production of HIF-1 and TNF-alpha in the myocardium and other body tissues, activates monocytes/macrophages that can produce pro-inflammatory cytokines, enzymes, and pro-oxidants [7].

It has been shown that in CHD patients with ICMP, a deficiency of HIF-1alpha and an excess of HIF-2alpha (40,74% of patients had non-zero values) were detected, in comparison with the normal content of these molecules in CHD patients without ICMP (Tab. 1). According to the manufacturer «Cloud-Clone-Corp» (USA) ELISA kits for detecting HIF-2alpha, its concentration in the blood of healthy individuals is not determined. Such an imbalance of HIF concentration in blood is typical for chronic oxygen deficiency [1, 2] and reflects an ongoing and, hence, ineffective adaptation to hypoxia in ICMP patients, which is absent in CHD patients without ICMP. At the same time, a deficiency of HIF-1alpha prevents an increase in MCP-1 concentration in patients with ICMP (r=0,66; p<0,05).

We had found an increased peripheral blood level of MCP-1 in CHD patients without ICMP and only a tendency to increase in it in patients with ICMP (in comparison with the group of healthy donors). MCP-1 is an important factor in the pathogenesis of CHD, since it attracts monocytes to atheroma, the focus of ischemia or necrosis [8, 9]. An excess of MCP-1 in peripheral blood at CHD without ICMP could have not only a pathological, but an adaptive significance, since this cytokine is involved in neoangiogenesis [9]. Therefore, the absence of MCP-1 hyperproduction in patients with ICMP (who, like CHD patients without ICMP, suffer from atherosclerosis), on the one hand, can be considered as a negative factor in the development of collateral circulation and inhibition of myocardial contractility, and, on the other hand, as a sign of hypoergia of the immune response against the background of atherosclerosis.

Table 1.

Concentration of hipoxia-inducible factors and cytokines in the blood of patients with heart failure (Me [Pe25; Pe75])

The content of mediators in the blood	Group of surveyed persons		
	CHD patients without ICMP	CHD patients with ICMP	Healthy donors
HIF-1alpha, ng/ml	0,051 [0,040; 0,138]	0,037 [0,020; 0,045] Pc=0,0353	0,080 [0,052; 0,096]
Percentage of patients with a positive result of HIF-2alpha determination in the blood, %	0	40,74±10,95% Pc=0,009 P =0,009	0
IFN-gamma, pg/ml	0	0	3,02 [0,50; 5,40]
IL-10, pg/ml	24,00 [23,00; 28,50]	30,05 [24,75; 33,50] Pc=0,026	19,50 [18,00; 24,00]
MCP-1, pg/ml	225,0 [182,0; 280,0] Pc=0,047	205,0 [170,0; 260,0]	175,0 [145,0; 207,5]
TNF-alpha, pg/ml	1,16 [0,90; 2,37] Pc=0,0492	2,23 [1,06; 7,12] Pc=0,0358	0,46 [0,00; 0,83]

Note. CHD - ischemic heart disease, ICMP - ischemic cardiomyopathy, Pc - the level of statistical significance of differences in indicators compared with healthy donors (control), P - the level of statistical significance of differences between groups of the patients.

The immunosuppression in patients with ICMP is confirmed by a high content of IL-10 in the blood, which is absent in CHD patients without ICMP (Tab. 1). As an anti-inflammatory and immunosuppressive mediator, IL-10 suppresses the secretion of pro-inflammatory cytokines and macrophage function [10]. At the same time, in both groups of patients with CHD, a deep deficiency of IFN-gamma in the form of zero value of its concentration in the blood was detected. The latter is generally typical for chronic heart failure of both ischemic and non-ischemic origin, in which a deficiency of interferon-gamma (IFN-gamma) is found despite an increase in the number of CD4+ T-lymphocytes in patients [11]. This allows us to think about the qualitative inferiority of cell-mediated immunity, which in ICMP is more pronounced due to the accumulation of IL-10 in the blood (Tab. 1). Since IL-10 hyperproduction is characteristic of adaptation to long-term hypoxia [12], the excess of this cytokine in the blood of patients with ICMP is obviously due to widespread myocardial ischemia, in contrast to transient focal ischemia at CHD without ICMP.

Conclusion. Thus, CHF against the background of CHD, regardless of the presence of ICMP, is characterized by a high content of TNF-alpha and a deficiency of IFN-gamma, which reflect the activation of nonspecific resistance mechanisms in atherogenesis and the lack of cell-mediated immunity. At the same time, the development of ICMP is associated with more pronounced immunosuppression, consisting in the accumulation of anti-inflammatory IL-10 and the absence of an increase in the concentration of pro-inflammatory MCP-1 in the blood. Such changes are obviously caused by a violation of the adaptation of patients with ICMP to hypoxia in the form of an excess of HIF-2alpha with a deficiency of HIF-1alpha in the blood, which induces the development of immunosuppression.

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

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胰岛素样生长因子（IGF-I），肿瘤坏死因子α（TNF-α）和白介素10（IL-10）：在溃疡性结肠炎的发病机制中发挥作用

INSULIN-LIKE GROWTH FACTOR (IGF-I), TUMOR NECROSIS FACTOR ALPHA (TNF-A) AND INTERLEUKIN 10 (IL-10): A ROLE IN THE PATHOGENESIS OF ULCERATIVE COLITIS

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抽象。在治疗过程中检查了55名UC严重程度不同的患者。通过ELISA测定外周血中的胰岛素样生长因子IGF-1和单核细胞中的细胞因子TNF-α和IL-10。我们研究了粘膜固有层的炎性浸润的细胞组成。

已发现在溃疡性结肠炎恶化期间，外周血中的IGF-I含量降低，并且TNF-α和IL-10的合成增加。患者血清中IGF-I的含量与UC的严重程度，SOTC中炎性反应的程度和TNF-αMNC的产生呈负相关，与IL-10的产生呈正相关。 UC临床缓解的发展伴随着IGF-I产生的增加，TNF-α合成的减少以及IL-10产生的正常化。

关键词：溃疡性结肠炎，胰岛素样生长因子，肿瘤坏死因子-α，白介素-10。

Abstract. *55 patients with varying severity of UC were examined in the course of treatment. Determination of insulin-like growth factor IGF-I in peripheral blood and cytokines TNF-a and IL-10 in mononuclear cells was performed by ELISA. We studied the cellular composition of the inflammatory infiltrate of the lamina propria of the mucous membrane.*

It was found that during the period of exacerbation of ulcerative colitis, the IGF-I content in the peripheral blood is reduced, and the synthesis of TNF-a and IL-10 is increased. The content of IGF-I in the serum of patients was inversely related to the severity of UC, the degree of inflammatory response in the SOTC and the production of TNF-α MNC, and in the direct relationship with the production of IL-10. The development of clinical remission of UC was accompanied by an increase in IGF-I production, a decrease in TNF-α synthesis, and a normalization of IL-10 production.

Keywords: ulcerative colitis, insulin-like growth factor, tumor necrosis factor-alpha, interleukin -10.

Ulcerative colitis (UC) constitutes a large group of inflammatory bowel diseases (IBD), which includes Crohn's disease (CD), as well as collagen, lymphatic, eosinophilic and non-specific colitis. UC is characterized by immuno-inflammatory damage to the colon, the development of which is mediated by immunological mechanisms. Inflammation in UC is superficial and affects only the mucous membrane and submucosa of the large intestine (MMLI), occurs exclusively in the colon [1, 2].

Despite a significant number of works devoted to the study of the etiology of UC, the causes of this pathology are still unknown, and the development mechanisms are not fully understood [3].

In the literature, there is a sufficient amount of information about disorders in the functioning of immunocompetent cells in UC, which determines the peculiarity of morphological changes in tissues in the area of inflammation and the course of the process according to the principle of a vicious circle, which makes it extremely difficult to regenerate damaged tissues and restore homeostasis [4].

To date, there is no consensus on the reasons for the emergence and development of UC. It is believed that a key link in the pathogenesis of UC is a violation of the T-cell link of the immune system, resulting in an imbalance between pro- and anti-inflammatory cytokines. Recently, the role of peptide growth factors, which are produced by cells of many types, including the intestinal epithelium, has been actively discussed, which can modulate the inflammatory response and proliferative activity of the intestinal epithelium with the participation of various cytokines (IL-10, TNF-α, IL-19, IL -37, etc.) [5] These substances belong to the family of insulin-like growth factors (IGFs), which are expressed in various parts of the gastrointestinal tract. IGF-1 is one of the most potent natural stimulants of cell growth and proliferation of various cell types in the body. Moreover, IGF-1 plays an important role in human physiology by controlling the metabolism of proteins, fats, and carbohydrates and stimulating glucose transport to muscles [6, 7].

Despite few studies evaluating the biological effects of IGF-I in UC, their role in the immunopathological process is quite obvious [8].

Purpose: defining the role of IGF-I in the pathogenesis of UC.

Material and methods: We examined 55 patients with different severity and endoscopic (Mayo index) UC activity in the dynamics of treatment. Clinical activity and severity of UC were assessed according to Truelove and Witts criteria. Drug therapy was prescribed according to the severity of the UC. The control group consisted of 20 healthy volunteers. Determination of IGF-I in peripheral blood was carried out by ELISA (Mediagnost, Germany). The results were ex-

pressed in nmol/l. The serum IGF-I level in the control group was 120.295 ± 10.723 nmol/l.

The content of TNF-a and IL-10 in mononuclear cells (MNC) of peripheral blood was determined by ELISA using standard Cytokin test systems (Russia). Cells were isolated from heparinized blood on a ficoll-verografin density gradient. After centrifugation, MNCs were removed in turn, washed with medium 199, and diluted in 1 ml of a special culture medium (RPMI-1640 with glutamine, 2% fetal calf serum, gentamicin solution 20 μg/ml). The number of cells was counted in the Goryaev chamber, standardized (2×10^6/ml), incubated for 24 hours at 37°C in an atmosphere of 5% CO_2 without (spontaneous synthesis) and in the presence of lipopolysaccharide (LPS), E. Coli ("Sigma", USA) - 10 μg/ml (stimulated synthesis).

The production of MNC TNF-a and IL-10 in the control group was, respectively: spontaneous-1.54+0.9 ng/2×10^6 and LPS-stimulated - 2.81+0.21 ng/2×10^6 and 5.52±1.39 and 9.17±1.51 pg/2×10^6 cells, P <0.05. The intensity of the inflammatory process in MMLI was studied using the method of Avtandilov G.G. with the calculation of the inflammatory infiltrate (in%) of the lamina propria of the mucous membrane. Studied the cellular composition of the inflammatory infiltrate. The results were statistically processed using SPSS 13.0 software.

Results and discussion: During the period of exacerbation of UC, the amount of IGF-I in the blood plasma was reduced (15.16 ± 1.35 nmol/l, P <0.05 with control).

In a comparative analysis of the IGF-I content in peripheral blood, taking into account the severity of UC, an inverse relationship was found - with an increase in the severity of UC, the level of IGF-I in the blood serum decreased (Table 1).

Table 1

IGF-I level in peripheral blood in patients with varying severity of UC ($\overline{X} \pm m_{\overline{x}}$)

Indicator, nmol/l	Severity		
	Light (n=25)　　(1)	Medium (n= 22)　(2)	Hard (n=8)　　(3)
IGF-I	28,52±0,11* $P_1 < 0,05$	15,3±0,082* $P_2 < 0,05$	10,24±0,07* $P_3 < 0,05$

*- P < 0,05 in comparison with the control group, P_1 – differences in indicators of groups 1 and 2, P_2 – differences in indicators of groups 1 and 3, P_3 – differences in indicators of groups 2 and 3.

Table 2 presents data on the content of IGF-I in the blood plasma of UC patients, taking into account the degree of activity of the inflammatory-destructive process (Mayo index) in the MMLI.

Table 2

IGF-I content in blood plasma taking
into account the degree of endoscopic activity UC $(\overline{X} \pm m_{\overline{x}})$

Activity level (Mayo index)		IGF-I level, nmol/l
First (1) (n=28)		24,35±0,12*
Second (2) (n=17)		15,265±0,07*/**
Third (3) (n=10)		12,98±0,16*/**

*- $P < 0,05$ in comparison with healthy, ** - $P < 0,05$ in comparison with the 1st degree of activity.

An inverse relationship was established between the IGF-I content in the peripheral blood and the activity of the inflammatory-dystrophic process in MMLI - with an increase in the Mayo index, the IGF-I index decreased.

It was of particular interest to study the IGF-I index depending on the severity of the inflammatory response in MMLI. For this purpose, the examined patients underwent a morphometric study of MMLI rectobioptates with the calculation of the density of the inflammatory infiltrate (IID). Depending on the density of the inflammatory infiltrate, the patients were divided into two groups: the first - with a weak inflammatory reaction ($34.7 \pm 2.8\%$), the second - with a pronounced intensity of the infiltrate ($65.0\pm2.4\%$, $P < 0, 05$ with 1st group).

In order to elucidate the possible dependence of the intensity of the inflammatory process in MMLI on the level of serum IGF-I in patients with active UC, a correlation analysis was carried out (Table 3).

Table 3

Relationship Between IGF-I Index and Differing Inflammatory Infiltrate
Density (IID) in MMLI in UC Patients

	Correlation coefficient (rs)	
The investigated relationship	**Weak**	**Pronounced**
The density of the inflammatory infiltration		
IGF-I (nmol/l) and IID	- 0,315*	- 0,576*

Note : * – $P < 0,05$

It was found that with moderate (weak) severity of the inflammatory infiltrate in the MMLI, a weak negative relationship was determined between the IGF-I index and the density of the infiltrate in the MMLI. With a pronounced density of the inflammatory infiltrate, a strong feedback was traced.

Taking into account the fact that the expression of IGF-I is in a certain dependence on the production of certain cytokines [9], we tried to identify possible relationships of the studied peptide growth factor in the examined group of patients with the synthesis of the pro-inflammatory cytokine TNF-α and the anti-inflammatory cytokine IL-10 by peripheral blood mononuclear cells.

We found that the initial spontaneous and stimulated synthesis of MNC TNF-a (1 spontaneous - 5.9 ± 0.8 and 2 stimulated 8.2 ± 0.9 ng/2x10^6) and IL-10 (1 spontaneous – 9.57 ± 1.22 and 2.stimulated 15.9 ± 0.79 ng/2x10^6) in patients with active UC was significantly higher than the control values ($P_{1.2}$ <0.05 with control).

Correlation analysis was carried out between the production of MNC TNF-α, IL-10 and the IGF-I index in the peripheral blood of patients with active UC.

According to the data in Table 4, we found a reliable inverse relationship between the synthesis of TNF-α MNC under spontaneous and LPS-stimulated conditions and a positive one between the production of MNC IL-10 under spotted and stimulated conditions, on the one hand, and the level of IGF-I in peripheral blood on the other hand.

Table 4

Relationship between IGF-I level in peripheral blood and MNC production of TNF-α and IL-10 in patients with active UC

Studied indicator	Rank correlation coefficient (rs)	
	Synthesis of TNF- α MNC	Synthesis of IL-10 MNC
IGF-I	-0,453* -0,516*	0,512* 0,497*

Note: in the numerator - spontaneous production, in the denominator - induced by LPS. *- p< 0,05.

During the formation of clinical remission of UC (on average after 8 weeks), the peptide level increased to 94.125 ± 28.18 nmol/l, P <0.05 with an exacerbation phase, but did not reach the control values (P <0.05). The induction of clinical remission by UC was accompanied by a decrease in TNF-α MNC synthesis both in spontaneous (3.9 ± 0.5 ng/2x10^6) and LPS-stimulated conditions (5.3 ± 0.2 ng/2x10^6, $P_{1.2}$ <0.05 with aggravation and control). MNC IL-10 production normalized by this period of the disease (5.61 ± 0.31 and 9.72 ± 0.51 ng/2x10^6, $P_{1.2}$> 0.05 with exacerbation and control).

The regularities that we identified in the content of the studied peptide growth factor IGF-I in the blood serum of patients with various clinical forms of UC, in connection with mediators of the inflammatory process in MMLI, are not accidental and indirectly confirm their involvement in pathophysiological processes in the colon.

As noted previously, the biological effects of IGF-I in UC are poorly understood, and current research results are mixed. Growth factors, including IGF-I, have multiple functions and often oppositely directed actions in ulcerative colitis and Crohn's disease. We found that during the period of exacerbation of UC, the level of IGF-I in the blood serum was reduced, and in proportion to the severity of the next attack. Similar results were obtained by Thayu M. et al. [10]. In other studies, the authors did not find significant deviations in the IGF-I content in patients with active UC, in contrast to patients with CD, where the levels of this peptide were significantly higher than the control values [11].

Undoubted evidence of the important role of the insulin-like growth factor IGF-I in UC is its definite conjugation with the severity of the inflammatory reaction in MMLI and the synthesis of cytokines by mononuclear cells of the peripheral blood.

Being one of the central links of the human immune system, the cytokine system is able to respond to almost any pathological processes occurring in the intestine. In this case, the activation of immunocytes occurs, which ultimately, according to the studies, leads to a sharp increase in the level of not only pro, but also anti-inflammatory cytokines in the peripheral blood cells of patients with IBD [4].

Thus, we found an inverse relationship between the IGF-I level and TNF-α synthesis and a positive relationship between the studied pethid and IL-10. It is known that low production of the growth factor IGF-I can negatively affect the trophism of the intestinal epithelium in the active stage of inflammation and in the recovery period [12]. It has been shown that a long-term decrease in the IGF-1 level during UC can lead to impaired bone metabolism with an increased risk of osteoporotic fractures, which is often observed in this category of patients [13]. On the other hand, excessive accumulation of growth factors can cause aberrant proliferation of mucosal epithelium, which increases the risk of intestinal carcinoma, a known complication of IBD [14].

The experiment has shown that cytokines are able to regulate the expression of IGF-I in the intestinal epithelium by inhibiting growth hormone. Thus, TNF-α reduced the secretion of IGF-I in macrophages [15], and exogenous insulin-like factor associated with protein-3 (IGFBP-3) suppressed the production of TNF-α cytokine induced by the nuclear factor NF-kV [16]. In vitro, the protective role of IGF-I against the degradation of cartilage proteoglycans induced by interleukin-1 or TNF-α has been shown [17].

We believe that in the active phase of UC, proinflammatory cytokines can suppress the production of IGF-I, thus prolonging the immune-inflammatory process in MMLI. At the same time, the excessive production of anti-inflammatory IL-10 by blood immunocytes in acute UC is due to the high production of various proinflammatory mediators by the Th1-clone lymphocytes and is apparently aimed at

their suppression. At the same time, it is possible that this cytokine has a regulatory effect on IGF-I expression. It has been shown that IL-10 is able to inhibit the cellular inflammatory response, regardless of whether the cells involved in it belong to one or another subpopulation of T-helper lymphocytes, and to restore the tolerance of the mucous membrane to normal intestinal flora. Moreover, in an experiment on mice, it was shown that the administration of IGF-1 increases the expression of the anti-inflammatory cytokine IL-10 [18].

We found that during the formation of clinical remission of UC, against the background of immunomodulatory therapy, TNF-α synthesis naturally decreases, IL-10 MNC production is normalized, and the production of IGF-I growth factor increases, which provides regenerative activity of the intestinal mucosa epithelium during this period of the disease [19].

Advances in understanding the processes associated with the development of intestinal inflammation, in particular, the role of certain biological agents in the development of a pathological immune response, led to the development of the concept of targeted biological therapy. We believe that the study of the role of bioregulatory peptides, in particular, IGF-I in UC, may be essential for the search for new therapeutic targets.

Conclusions:

1. In the active stage of UC, the level of IGF-I is decreased, and the synthesis of MNC TNF-α and IL-10 is increased.

2. The content of IGF-I in the serum of patients was inversely related to the severity of UC, the degree of inflammatory response in MMLI, TNF-α production, and in a direct relation to the synthesis of IL-10 MNC.

3. The formation of clinical remission of UC was accompanied by an increase in IGF-I production, a decrease in TNF-α synthesis, and a normalization of IL-10 MNC production.

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不同年龄儿童的急性呼吸功能不全
ACUTE RESPIRATORY INSUFFICIENCY IN CHILDREN OF DIFFERENT AGES

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抽象。 本文介绍了在SBHCI RB CCCH No.17的1号和3号儿科病房接受治疗的1至18岁（n = 162）支气管阻塞综合征儿童的临床和记忆删除差异的评估结果。 乌法。 研究获得的结果表明，统计学上显着的年龄优势（p ＜001），支气管阻塞综合征发作次数（p ＜001），血液中IgE水平（p ＜001），各种触发因素的影响 （p ＜001）与小儿急性阻塞性支气管炎患儿相比，支气管哮喘患儿的患病率更高。 因此，在患有急性阻塞性支气管炎和支气管哮喘的儿童中，支气管阻塞综合征具有许多发育特征，这在儿科实践中很重要。
关键词：支气管阻塞综合征，支气管哮喘，急性阻塞性支气管炎，儿童

Abstract. *The article presents the results of an assessment of clinical and anamnestic differences in children with broncho-obstructive syndrome from 1 to 18 years old (n = 162), who were treated in pediatric wards № 1 and № 3 of the SBHCI RB CCCH № 17 of Ufa. The obtained results of the study demonstrate a statistically significant predominance of age (p <001), the number of episodes of broncho-obstructive syndrome (p <001), IgE levels in the blood (p <001), the effect of various triggers (p <001) in patients with bronchial asthma compared with children with acute obstructive bronchitis. Thus, broncho-obstructive syndrome has a number of developmental features in children with acute obstructive bronchitis and bronchial asthma, which is important to consider in pediatric practice.*

Keywords: *broncho-obstructive syndrome, bronchial asthma, acute obstructive bronchitis, children*

Introduction

In pediatric practice, the most common diseases of the respiratory system. Their frequency of occurrence in different seasons of the year varies from 50 to 90% of cases. So, according to Rosstat data, in 2017, 30006.9 children fell ill with respiratory diseases, and in 2018 - 30305.9 children [1]. It should be noted that respiratory diseases are the main cause of infant mortality, and in the Russian Federation they rank third after perinatal pathology and malformations. It was established that in 2018 384 children died under the age of 1 year, which is less than in 2017 - 431 children died [1]. Mostly this outcome is associated with the development of acute respiratory failure (ARF).

Acute respiratory failure (ARF) - is a pathological condition in which the gas composition of arterial blood is disturbed and hypoxemia and hypercapnia develop. Depending on the pathogenesis, hypoxemic, hypercapnic and mixed ARF types are distinguished. There are two types of RF. Type I RF (hypoxemic, parenchymal) affects the alveoli, alveolar-capillary membrane, and pulmonary blood flow. It can be caused by a bacterial or viral infection, pneumonia, pneumonitis, pulmonary edema, fibrosing lung diseases. Type II RF (hypercapnic, ventilation) is characterized by changes in the ventilation apparatus; obstructive or restrictive processes may serve as its cause [2].

According to the severity of the process, acute RF, chronic RF and acute RF against the background of chronic are distinguished. These forms of RF differ in their acid-base composition [2].

According to the severity, only chronic RF is classified, in which the level of hypoxemia can also predict the deterioration or stabilization of the condition. For example, with grade 3 chronic RF, the likelihood of death is high. In acute RF, the degree of hypoxemia in different nosologies has a different prognosis. Thus, mild hypoxemia in bronchial asthma indicates a severe exacerbation, and in chronic obstructive pulmonary disease it does not always indicate an unfavorable outcome [2].

The formation of ARF in children is predisposed by their anatomical and physiological features of the respiratory system. These include: relatively lower activity of surfactant, chest of "expiratory" structure, high standing of the diaphragm, weakness of the respiratory muscles, narrow airways, relatively low excitability of the respiratory center during hypoxemia and hypercapnia, high hemoglobin content in the blood, physiological tachypnea, low lung compliance, a large number of collagen fibers and fewer elastic fibers, underdevelopment of airway cartilage [3]. The final differentiation of the lung is completed at 7 years of age.

In addition, certain common causes of ARF are characteristic for each age group of children. So, in newborns it is prematurity and congenital heart and lung defects, in children of the first 2 years of life - respiratory infections and heart disease, at 7-12 years old - bronchial asthma [3].

Also, for different age groups, a certain form of RF is characteristic. In newborns, obstruction of the upper respiratory tract occurs predominantly, in young children and in school-preschool age - the lower respiratory tract. The exception is children with respiratory distress syndrome and disseminated diseases, they are characterized by the parenchymal form of RF [4]. The RF clinic is also different depending on the age. For example, infants often have decreased activity, irritability and seizures. In preschoolers and schoolchildren, fatigue, weakness, intellectual disability, and sweating are the first to be diagnosed [4].

The development of RF is based on various etiological factors. Among viral etiology, rhinoviruses, repiratory syncytial viruses and parainfluenza predominate. In this case, rhinovirus infection usually causes obstruction of the lower respiratory tract, and parainfluenza - the upper respiratory tract. It should be noted that young children infected with rhinoviruses often end up in the intensive care unit [5].

In the development of ARF, risk groups are distinguished. A number of authors [6] in their work established that the risk group for RF development includes premature infants and newborns with a gestational age of 37 weeks who were born by caesarean section. In infants with a gestational age of 37 weeks, severe RF is associated with intrauterine growth retardation, the main cause of which is a scar on the uterus. According to some authors, in the presence of a scar on the uterus after an operative delivery, complications such as anemia of pregnant women, gestosis, chronic placental insufficiency occur [6].

Thus, respiratory failure is common in pediatric practice and is one of the causes of infant mortality. Moreover, children of different ages have their own characteristics of the development of respiratory failure.

Purpose of the study

To assess the differences in clinical and anamnestic manifestations in children with respiratory diseases accompanied by respiratory failure due to bronchial obstruction syndrome.

Materials and methods

During 2019, on the basis of SBHCI RB CCCH № 17 of Ufa in pediatric departments № 1 and № 3, a comparative study of children with respiratory diseases accompanied by broncho-obstructive syndrome was carried out. There were 162 children under our supervision.

The selection of patients was carried out according to the following criteria: patients aged 1 to 18 years, hospitalized for inpatient treatment with verified diagnoses of bronchial asthma (BA) and acute obstructive bronchitis (AOB), accompanied by BOS, for the provision of emergency medical care - relief of bronchial obstruction ; patients with clinical manifestations of respiratory failure (RF) I and II degrees.

Exclusion criteria: patients with grade III RF clinical manifestations as they required intensive care.

During the study, an analysis of medical records was carried out - the medical record of an inpatient (form № 003/y) and data from the patient's outpatient card (form №112/y). Assessment of the medical history; general clinical and physical examination of the patient, as well as the necessary volume of laboratory and instrumental diagnostics (general blood test, general urine analysis, biochemical blood test, chest X-ray examination, pulse oximetry, for children over 6 years old - spirometry) in accordance with the clinical recommendations "Acute bronchitis in children "and" Bronchial asthma in children "2017.

The patients we observed were divided into 2 groups according to the underlying disease: the first group - children with a diagnosis of acute obstructive bronchitis, verified in accordance with the clinical guidelines "Acute bronchitis in children" 2017; the second group - children with a previously established diagnosis of bronchial asthma.

The severity of BOS in patients was assessed according to the severity of clinical RF symptoms - respiratory rate per minute, participation of auxiliary muscles in the act of breathing, pulse rate, and pulse oximetry indicators. When assessing the severity of BOS, the auscultatory picture in the lungs was also taken into account - the presence of dry wheezing and the presence of a dry, unproductive cough.

For children, in a hospital setting, emergency medical care measures were taken aimed at stopping an attack of bronchial obstruction using a combined drug - a solution for inhalation of ipratropium bromide and fenoterol (Berodual®) with 0.9% sodium chloride solution in an approved age-specific dosage through a compressor nebulizer in within 7-10 minutes with an interval of 20 minutes up to 3 inhalations. If necessary, the observed children underwent oxygen therapy (with saturation less than 90%) and airway sanitation. All measures taken were aimed at eliminating bronchospasm, reducing vasosecretory disorders, thinning and removing sputum, and eliminating respiratory failure [6, 7].

Statistical processing of results

Statistical analysis was carried out using the statistical package "Statistica 10.0". The critical value of the level of statistical significance when testing null hypotheses was taken equal to 0.05. Taking into account the absence of normal distribution, the comparison of the central parameters of the groups was carried out using the nonparametric methods of Kolmogorov-Smirnov, Mann-Whitney, the values of quantitative variables are given as a median, 25% and 75% quartiles of Me [Q1; Q3].

Results and discussion.

The number of children with acute obstructive bronchitis was 44.4% (n = 72), with bronchial asthma - 55.6% of children (n = 90). The age and gender structure of patients with AOB and BA is presented in Table 1.

Table 1

Age and gender structure of patients with acute obstructive bronchitis and bronchial asthma

Group	Indi-cators	Number of obs. n (%)	Av. val.	Me-dian	25% per-cent-mul	75% percent-mul	St. dev.	Rel.int. st. dev. 95.00%	Rel.int. st. dev. +95.00%
Children with AOB	boys	44,00 (61,11)							
	girls	28,00 (38,89)							
	total	72 (100,00)							
	Patient age	-	4,1667	5,0000	1,0000	6,5000	2,9263	2,5141	3,5014
Children with BA	boys	56,00 (62,22)							
	girls	34,00 (37,78)							
	total	90 (100,00)							
	Patient age	-	9,0667	9,0000	6,0000	11,0000	3,172	8,4023	9,7311

Note: AOB – acute obstructive bronchitis, BA – bronchial asthma

Median age, 25% and 75% quartiles Me [Q1; Q3] examined children with AOB were 5 [1; 6.5] years, and patients with BA - 9 [7; 11] years. The prevalence of boys was characteristic both among patients with AOB up to 61.11% (n = 44) and with BA up to 62.22% (n = 56).

The structure of the degree of RF in patients with AOB and BA admitted to pediatric wards is presented in Table 2.

Table 2

Structure of RF degree in patients with acute obstructive bronchitis and bronchial asthma

Group	Indica-tors	Number of obs. n (%)	Av. val.	Me-dian	25% per-cent-mul	75% per-cent-mul	St. dev.	Rel.int. st. dev. 95.00%	Rel.int. st. dev. +95.00%
Children with AOB	RF I	53 (73,61)	0,7361	1,0000	0,0000	1,0000	0,4438	0,3813	0,5310
	RF II	19 (26,39)	0,2639	0,0000	0,0000	1,0000	0,4438	0,3813	0,5310
	total	72 (100,0)							
Children with BA	RF I	62 (68,89)	0,6889	1,0000	0,0000	1,0000	0,4655	0,5914	0,7864
	RF II	28 (31,11)	0,3111	0,0000	0,0000	1,0000	0,4655	0,2136	0,4086
	total	90 (100,00)							

Note: AOB – acute obstructive bronchitis, BA – bronchial asthma

When assessing the degree of RF in children with AOB and BA, RF of I degree was detected more often and amounted to 53 (73.81%) and 62 cases (68.89%), respectively.

According to the Kolmogorov-Smirnov, Mann-Whitney criteria, in a group comparison of the anamnesis data of patients with AOB (n = 72) and BA (n = 90), significant differences were found in age, the number of episodes of BOS, blood IgE levels, and BOS triggers. The data presented in Tables 3 and 4 indicate more frequent episodes of BOS and the influence of various triggers on their development in the presence of BA in children.

Table 3

Statistically significant indicators of the anamnesis of children with acute obstructive bronchitis and bronchial asthma according to the Kolmogorov-Smirnov test

Variables		p-level	Average group 1	Average group 2	St.dev. group 1	St.dev. group 2	N 1 group	N 2 group
age of patients (years)		**p < .001**	**4,1667**	**9,0667**	**2,9263**	**3,1722**	72	90
number of episodes of BOS		**p < .001**	**1,0000**	**1,5778**	**0,8391**	**0,7640**	72	90
IgE level (IU/ml)		**p < .001**	**37,6250**	**261,511**	**36,1395**	**423,344**	72	90
BOS triggers	acute respiratory infection	**p < .001**	**0,7222**	**0,3777**	**0,4510**	**0,4875**	72	90
	physical exercise	p < .001	0,0000	**0,7444**	**0,0000**	**0,4386**	72	90
	medications	**p < .001**	**0,0416**	**0,4666**	**0,2012**	**0,5016**	72	90
	emotions, laughter	p < .025	0,0000	0,2444	0,00000	**0,432165**	72	90
	harsh odors	**p < .05**	**0,0000**	**0,2222**	**0,0000**	**0,418069**	72	90
	exacerbation of allergic rhinitis	**p < .005**	**0,0000**	**0,2777**	**0,0000**	**0,4504**	72	90

Note: the criteria are significant at the p <0.05 level.

BOS - broncho-obstructive syndrome

Table 4

Statistically significant indicators of the anamnesis of children with acute obstructive bronchitis and bronchial asthma according to the Mann-Whitney U test

Variables	U - criterion	Z - value	P - level	Z corrected	P - level	N 1 group	N 2 group
age of patients (years)	909,500	**-7,8535**	**0,0000**	**-7,9055**	**0,0000**	72	90
number of episodes of BOS	2112,000	**-3,8004**	**0,0001**	**-4,0882**	**0,0001**	72	90

IgE level (IU/ml)		1890,500	**-4,5470**	**0,0001**	**-4,5934**	**0,0001**	72	90
BOS triggers	acute respiratory infection	2124,000	**3,7599**	**0,0001**	**4,3498**	**0,0001**	72	90
	physical exercise	828,000	**-8,1282**	**0,0000**	**-9,5289**	**0,0000**	72	90
	medications	1863,000	**-4,6396**	**0,0001**	**-5,9804**	**0,0000**	72	90
	emotions, laughter	2448,000	**-2,6678**	**0,0076**	**-4,4960**	**0,0001**	72	90
	harsh odors	2520,000	**-2,4251**	**0,0153**	**-4,2562**	**0,0001**	72	90
	humidity	2736,000	-1,6971	0,0896	**-3,4871**	**0,0004**	72	90
	cold air	2718,000	-1,7577	0,0787	**-3,1540**	**0,0016**	72	90
	exacerbation of allergic rhinitis	2340,000	*-3,0318*	*0,0024*	**-4,8454**	**0,0001**	72	90
dry cough		2835,000	1,3634	0,1727	**2,1122**	**0,0346**	72	90

Note: the criteria are significant at the p <0.05 level;

BOS – broncho-obstructive syndrome

Analysis of clinical manifestations in patients with BOS at the time of admission to the hospital made it possible to identify the main group of symptoms: a change in the nature and frequency of respiratory movements per minute, the participation of auxiliary muscles in the act of breathing, a change in the pulse rate and pulse oximetry indicators, the presence of dry cough and the presence of dry wheezing on auscultation. The clinical manifestations of BOS in children with AOB and BA were similar, only the manifestations of dry cough prevailed statistically significantly in children with AOB (Z score = 2.1122; p = 0.0346) according to the Mann-Whitney U test.

These symptoms were also taken into account over time after 24 hours to assess the effectiveness of bronchodilator therapy. The relief of the main clinical symptoms in a group of children with bronchial asthma was observed on days 1-3 from the beginning of the nebulizer bronchodilator therapy in a hospital setting; in children with acute obstructive bronchitis, the relief of clinical symptoms of bronchial obstruction was noted on days 4-5.

Conclusions

1. According to the gender characteristics, the prevalence of broncho-obstructive syndrome in boys was revealed. Moreover, more often children develop respiratory failure of the 1st degree.

2. Analysis of the patient's anamnesis revealed a statistically significant predominance of age, the number of episodes of broncho-obstructive syndrome, the level of IgE in the blood, the effect of various triggers in patients with bronchial asthma in comparison with children with acute obstructive bronchitis.

Thus, broncho-obstructive syndrome has clinical and anamnestic developmental features in children with acute obstructive bronchitis and bronchial asthma, which is important to consider in pediatric practice.

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低强度微波噪声信号影响下热创伤止血系统参数的变化
DYNAMICS OF HEMOSTATIC SYSTEM PARAMETERS IN THERMAL TRAUMA UNDER THE INFLUENCE OF LOW-INTENSITY MICROWAVE NOISE SIGNALS IN VITRO

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抽象。　本文分析了比较研究的结果，这些研究评估了超高频（EHF）和太赫兹（THz）范围的电磁辐射（EMR）的低强度噪声信号对体外热损伤过程中止血系统指标的影响 。　在伤口和烧伤的复杂治疗中，注意力集中在使用微波来有针对性地调节血液流变状态的可能性上。
关键词：电磁辐射，极高频率范围，太赫兹范围，止血系统

***Abstract.** The article analyzes the results of comparative studies assessing the effect of low-intensity noise signals of electromagnetic radiation (EMR) of the extremely high-frequency (EHF) and terahertz (THz) ranges on the indicators of the hemostasis system during thermal injury in vitro. Attention is focused on the possibilities of using microwaves for the targeted regulation of the state of hemorheology in the complex treatment of wounds and burns.*

***Keywords:** electromagnetic radiation, extremely high frequency range, terahertz range, hemostatic system*

Thermal injuries cause a complex of pathophysiological disorders of a local and systemic nature, among which hemostasiological complications are of fundamental importance, which have a negative effect on the body and disrupt the course of reparative processes [1]. Recently, among the corrective biomedical technologies, a significant place belongs to electromagnetic radiation (EMR) therapy of the extremely high frequency (EHF) and terahertz (THz) ranges with a proven complex effect on the body, including the hemostasis system [2]. Academic interest in the problem is constrained by the lack of a clear physical explanation and a unified view of the mechanism for the development of responses that arise in

biological systems to the action of microwaves. It is believed that the mechanism of action of EHF therapy is due to the ability of EMR EHF to enhance the generation of acoustoelectric oscillations of cell membranes (Fleerich oscillations), which are inherent in all living cells and are aimed at maintaining homeostasis. In pathology, these fluctuations damp, and with death, the cells disappear completely. Another mechanism for realizing the effect of EHF-therapy is the ability of this radiation to enhance the convective motion of a liquid. In this case, its mixing occurs, including in the near-membrane layers, which leads to an acceleration of membrane transport processes [3]. Scientists from various scientific schools interpret ambiguously the contribution of the main metabolite molecules (nitric oxide, singlet oxygen, water) to the formation of recorded bioeffects [4]. However, the mechanisms of development of these systemic reactions remain not fully understood and insufficiently understood.

The purpose of this work was a comparative study of the effect of broadband signals of the EHF and THz ranges on the parameters of the hemostasis system in thermal injury in in vitro experiments.

Material and methods. The study of the state of the viscoelastic properties of blood was carried out in the process of exposure to EMR EHF and THz radiation sources using devices: "Amfit-0.2/10-01" (PhysTech NNSU, Nizhny Novgorod) with a frequency range of 53.57-78.33 GHz ; its experimental model with a frequency range of 130-170 GHz, which contains the molecular emission and absorption spectrum (MEAS) of O_2 and NO, and an experimental millimeter-wave noise signal generator (IPM RAS, Nizhniy Novgorod) with a frequency range of 150.176-150.664 GHz (corresponds to MEAS NO). The average power of all devices used in the experiment was 0.2-10 µW/cm² (3 times higher than the threshold cell sensitivity to noise EMR), which allows the body to adjust itself to the desired frequency and minimizes possible side effects.

Blood samples from 51 patients with burn injury were irradiated: in 11 cases the exposure was carried out in the range of 53.57-78.33 GHz, in 22 cases - 130-170 GHz, in 18 cases - in the frequency range 150.176-150.664 GHz. The power level in all cases was identical and amounted to 1 mW with a uniform spectrum of the noise power density + 2 dB. Exposure to EMR on citrated blood samples with a volume of 340 µL placed in a disposable cuvette was carried out in the mode of direct irradiation with EMR noise ranges with an exposure of 5 and 30 minutes. The study of the viscoelastic properties of blood was carried out according to the standard method. Measurement of thromboelastographic parameters was performed on citrated blood samples with the addition of an activator koalin (TEG mode - citrated kaolin). All indicators of the kinetics of clotting, issued by this program, were obtained, the indicators of TEG were subjected to statistical analysis: R, K, a, MA, G. The first three indicators (R, K, α) characterize mainly the state

of the coagulation system and clearly correlate with the main phases of thrombus formation modern cell (cell-base) blood coagulation model: R - initiation, K - amplification, angle α - propagation [5].

To test statistical hypotheses, Student's t-test and Mann-Whitney U-test were used. The critical value of the significance level was taken equal to 0.05. Quantitative data are presented as M±σ, as well as the median and the first; third quartile Me (Q1; Q3). The frequency of observation is given in percentage, absolute values are indicated in parentheses. Statistical data processing was carried out using the Statistica 6.0 software (Stat Soft, Inc.)

Results and discussion. Analysis of the conducted in vitro studies showed that exposure to the broadband EMR EHF range of 53.57-78.33 GHz had a potentiating effect on the initiation (R) and enhancement (k) phases of blood coagulation, both at 5 and 30 minutes exposure. At the same time, the effect of this radiation range on the propagation phase (α) and the mechanical properties of the blood clot (MA and G) was not recorded (Table).

Table

Dependence of the dynamics of the viscoelastic properties of blood on the EMM spectrum and exposure to radiation

Indicators	EMR 130-170 GHz (n=18)			EMR 150,179-150,664 GHz (n=22)			EMR 53,57-78,33 GHz (n=11)		
	Exposure time			Exposure time			Exposure time		
	before	5	30	before	5	30	before	5	30
R	9,90 [8,00; 10,8]	7,15 [6,00; 8.60] $P1=0,002$	7,60 [6,70; 9.20] $P2=0,02$ $P3>0,05$	7,20 [5,40; 7,90]	6,25 [5.50; 8.20] $P1>0,05$	8.05 [6,60; 8,60] $P2<0,05$ $P3>0,05$	7,8 [6,2; 9,8]	6,2 [5,5; 8,7] $P_1>0,05$	6,3 [5,2; 7,2] $P_2=0,026$ $P_3>0,05$
k	2,20 [2,10; 2,70]	2,15 [1,60 ;2,90] $P1>0,05$	3,55 [2,60; 4,40] $P2=0,01$ $P3=0,0006$	1,40 [1,20; 1,50]	1,80 [1,70; 2,40] $P1<0,05$	2,75 [6,60; 8,60] $P2<0,05$ $P3<0,05$	2,2 [1,2; 2,7]	1,8 [1,2; 2,7] $P_1=0.046$	1,5 [1,2; 2,7] $P_2>0,05$ $P_3>0,05$
alfa	59.6 [55.8; 64,3]	61.2 [53,0; 67,7] $P1>0,05$	50.8 [42,3; 60,2] $P2<=0,001$ $P3<0,00018$	68.5 [62,5; 72,1]	64.0 [56,2; 66,7] $P1=0,002$	55.4 [49,1; 64,5] $P2=0,0004$ $P3=0,04$	68,4 [57,0; 74,1]	70,0 [65,5; 73,3] $P_1>0,05$	69,3 [65,9; 74,0] $P_2>0,05$ $P_3>0,05$
MA	61,6 [60,6; 62,9]	61,9 [54,1; 64,8] $P1=0,03$	58,5 [52,3; 63,0] $P2=0,003$ $P3=0,005$	67,4 [63,8; 71,7]	64,2 [61,2; 69,9] $P1=0,049$	63,6 [57,9; 69,5] $P2=0,016$ $P3>0,05$	68,4 [64,2; 73,8]	70,5 [68,1; 74,6] $P_1>0,05$	68,7 [66,8; 73,0] $P_2>0,05$ $P_3=0.021$

G	8,20 [7,80; 12,7]	8,60 [6,00; 9,80] **P1=0,0008**	7,50 [5,80; 8,60] **P2=0,005 P3=0,013**	10,7 [8,80; 12,7]	9,46 [7,90; 11,6] P1>0,05	9,12 [6,90; 11,2] **P2=0,032** P3>0,05	10,3 [8,8; 14,1]	11,1 [10,6; 16,1] P$_1$>0,05	10,7 [9,7; 12,7] P2>0,05 P3>0,05

Note: n - the number of samples), * - the differences are statistically significant in the analyzed parameters between the control group and groups 1 and 2; ** - the differences are statistically significant for the analyzed parameters between groups 1 and 2.

P_1 – reliability of differences between TEG parameters before and after 5 minutes exposure to EMR EHF

P_2 – reliability of differences between TEG parameters before and after 30 minutes exposure to EMR EHF

P_3 – reliability of differences between TEG indicators after 5 and 30 minutes exposure to EMR EHF

Irradiation of blood samples with EMR THz with a frequency range of 130-170 GHz, which contains MSPI of oxygen and nitric oxide, both at 5 and 30 minutes of exposure, caused a shortening of the R interval, which indicated an activating effect on the initiation phase. At the same time, the first 5 minutes of exposure, the effect on the phases of propagation and enhancement of blood coagulation was not observed, while lengthening the irradiation time to 30 minutes caused a decrease in the activity of the coagulation cascade, as evidenced by the extended time of initial thrombus formation (k) and a decrease in the rate of clot formation (α). Irradiation with this spectrum also affected the properties of the formed clot: exposure for 5 minutes contributed to an increase in the clot density (MA, G), with an increase in the exposure to 30 minutes, its decrease (MA, G) was noted. This indicates that the effect of EMR at the frequencies of MEAS of oxygen and nitric oxide on the viscoelastic properties of blood has a dose-dependent effect: the potentiating effect as a result of 5 minutes of irradiation is corrected by an increase in the duration of irradiation, and after 30 minutes of exposure, the response of the hemostasis system has a hypocoagulation direction (Table), which must be taken into account in practice.

Exposure of blood samples to EMR THz at nitric oxide frequencies (150.176-150.664 GHz) did not lead to an increase in coagulation activity in any irradiation regime. After 5 minutes of exposure, the reaction time (R) did not differ from the initial one, while the values of the indicators reflecting the propagation (K) and amplification (α) phases indicated hypocoagulation. A decrease in the physical properties of the clot (MA, G) was noted at both 5 and 30 minutes of exposure (table).

Presumably, the mechanisms that determine the response of the hemostasis system to the effect of different ranges of EMR EHF and THz may be changes in the functional activity of proteins (transport proteins, enzymes that determine biochemical processes, as well as biomacromolecules embedded in membranes) in response to their confarmatory rearrangement under the influence of radiation [6]. In particular, a decrease in solubility, intrinsic viscosity, concentration dependence of the sedimentation constant and molecular weight of human fibrinogen has been shown in the process of increasing the dose of EMR exposure.

The data of a large number of experimental studies also indicate a high sensitivity of platelets to EMR EHF [7]. It is assumed that platelet activation is at least partially enhanced by the formation of reactive oxygen species and lipid peroxidation. In addition, a large role is assigned to calcium ions, which are the most important bioregulators of the pathophysiological processes of platelets and connect almost all stimuli with all reactions. The balance of the metabolism of calcium ions determines the stability of cell membranes.

Conclusion. The results of this study allow us to expand our understanding of the degree and mechanism of influence of various low-intensity ranges of microwave EMR on the development of protective hemostasiological reactions of the body in vitro. On the example of thermal injury at the cellular level, the dose-dependent effects of the EMR EHF influence on the hemostasis system parameters were registered, which requires a differentiated approach to the correction of hemostasiological parameters in the clinic. Potential negative effects of low-intensity EMR in the noise mode of radiation of the used frequency ranges in the in vitro system were not revealed. Further study of the mechanisms of the regulatory effects of microwaves, the creation of scientific foundations for their control using modern electronic devices is a promising task in the development of new medical technologies for many types of pathologies with systemic disorders of hemocoagulation processes, including the "plague of the 21st century" - a new coronavirus infection.

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低强度微波在体内实验性热损伤中对代谢和血管适应反应的诱导作用
EFFECT OF LOW-INTENSITY MICROWAVES ON THE INDUCTION OF METABOLIC AND VASCULAR ADAPTATION REACTIONS IN EXPERIMENTAL THERMAL TRAUMA IN VIVO

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抽象。 本文介绍了比较评价不同频率和能量特性的噪声电磁信号对热损伤体内代谢和血管适应反应指标影响的有效性的结果。 低强度太赫兹辐射在调节血管和代谢稳态中的保护作用，以及一氧化氮作为内源性血管扩张剂和神经递质的价值，在没有潜在负面影响的背景下具有抗炎和抗毒作用， 经过实验证实。

关键词：热损伤，太赫兹辐射，一氧化氮，微循环，氧化应激，抗氧化保护。

Abstract. The article presents the results of a comparative evaluation of the effectiveness of the influence of noise electromagnetic signals with different frequency and energy characteristics on the indicators of metabolic and vascular adaptation reactions in thermal trauma in vivo. The protective role of low-intensity terahertz radiation in the regulation of vascular and metabolic homeostasis, as well as the value of nitric oxide as an endogenous vasodilator and neurotransmitter with anti-inflammatory and antitoxic effects against the background of the absence of potential negative effects, was experimentally confirmed.

Keywords: thermal injury, terahertz radiation, nitric oxide, microcirculation, oxidative stress, antioxidant protection.

In connection with man-made disasters and local military conflicts, acute thermal injuries have become more frequent all over the world. The choice of the optimal approach to the treatment of such patients remains an important problem of modern combustiology. Correction of the arisen disorders of oxidative and energy

metabolism, as well as microcirculatory supply of damaged tissues is based on an integrated approach using all modern medical technologies capable of causing the development of adaptive vascular and metabolic reactions [1]. Currently, the use of low-intensity (LI) noise electromagnetic signals of the extremely high-frequency (EHF) and terahertz (THz) ranges, which differ in a minimal list of contraindications and side effects compared to other physical factors, has become relevant. This led to the creation of a domestic innovative technology of EHF-therapy with unique instrumentation [2]. Simulation in the EMR THz range of molecular emission and absorption spectra (MEAS) of intracellular messenger molecules (O_2, NO, CO, etc.), actively participating in regulatory processes, theoretically increases the effectiveness of its effect on the body [3]. An opinion is expressed about a more pronounced induction of the adaptive reactions of the body during physiopunctural exposure, due to the histomorphological and biophysical features of acupuncture points, which favorably distinguish them from the surrounding tissues [4]. However, the lack of a clear understanding of the patterns and mechanism of development of these reactions, a broad evidence base on the possible development of negative effects hinders the widespread introduction of the EHF-puncture method in practical medicine. This stimulated the need to continue experimental research conducted over a number of years on the basis of the University clinic of the Privolzhsky Research Medical University.

Purpose of the study: comparative assessment of the influence of the frequency-energy characteristics of noise electromagnetic signals on the indicators of metabolic and vascular adaptive reactions in experimental thermal injury.

Materials and methods

The experiment was carried out on 25 male Wistar rats weighing 310-360 g. All rats were kept under the same conditions. The experiments were carried out in accordance with the requirements of the Geneva Convention "International Guiding Principles for Biomedical Research Involving Animals" (Geneva, 1990) and the approval of the Local Ethics Committee FSBEI HE "PRMU" of the Ministry of Health of Russia, in accordance with the provisions of the Helsinki Declaration of 1975, revision of 2008.

We used an experimental model of contact thermal burn (CTB), which was applied under intramuscular anesthesia (Zoletil + Ksila), on a previously depilated back surface on an area of 20% of the body surface by a single three-second contact of an isolated skin area with a thermal heating element.

The animals were divided into 5 equal groups (two control and three experimental): intact rats (control 1), animals in the CTB state without subsequent irradiation (control 2). The rats of the experimental groups in the CTB state received a seven-day course of non-contact (at a distance of 5 mm from the device) irradiation in a continuous mode with a dose of 1.2 mJ to the occipital region at

the GV.14 point, where the skin projection of the autonomic regulation center responsible for the development of adaptive reactions of the body [6]. During the procedure, the rats were fixed in a special box. Three devices were used: "Amfit-0.2/10-01" (PhysTech NNSU, Nizhniy Novgorod) with the EHF EMR range of 53.57-78.33 GHz (therapeutic frequencies 50.3 GHz, 51.8 GHz, 65, 0GHz); its experimental model with a THz EMR range of 130-170 GHz (contains MEAS O_2 and NO) and an experimental millimeter-wave noise signal generator (IPM RAS, Nizhny Novgorod) with a THz EMR range of 150.176-150.664 GHz (corresponds to MEAS NO). The average power of the noise devices used in the experiment is 0.2-10 µW/cm² (3 times higher than the threshold cell sensitivity to noise EMP), which allows the body to adjust itself to the desired frequency and minimizes possible side effects.

Animals of the 3rd group (experiment 3) in the CTB state received EMR EHF irradiation with the range of 53.57-78.33 GHz, the rats of the 4th group (experiment 4) received EMR THz 130-170 GHz; Group 5 (experiment 5) - respectively, THz EMR 150.176-150.664 GHz.

The animals were taken out of the experiment at the end of a seven-day course of irradiation by decapitation under anesthesia (Zoletil + Ksila), using blood stabilized with sodium citrate (1: 9). The activity of free radical oxidation (FRO) processes in plasma and erythrocytes was studied using the method of induced biochemiluminescence on BChL-06 (Nizhny Novgorod), evaluating the parameters characterizing the total antioxidant activity (TAA) and the ability of a biological object to lipid peroxidation (LPO). The LPO intensity was determined by the level of malondialdehyde (MDA), superoxide dismutase (SOD) activity. The activity of catalase and lactate dehydrogenase (LDH) in direct and reverse reactions, glutathione reductase (GR) and glucose-6-phosphate dehydrogenase (Gl-6-fDH) was determined by spectrophotometric method [6].

The dynamics of microcirculation in the border area of the burn injury was monitored according to the data of laser Doppler flowmetry (LDF) before injury and on the 7th day after CTB under combined anesthesia (Zoletil + Ksila). The integral index of microcirculation (IM), which characterizes the degree of tissue volume perfusion per unit time, was assessed using a LAKK-M laser blood flow analyzer (SPA "Lazma", Russia) using wavelet analysis, which makes it possible to evaluate the components of microvessel tone based on the magnitudes of the amplitudes of microcirculation oscillations.

The significance of the differences between the indicators was determined using the Student's t-test. To test statistical hypotheses, the Mann-Whitney U-test was used. The critical value of the significance level is taken equal to 0.05. Quantitative data are presented as median and first; third quartile Me (Q1; Q3). The frequency of observation is given in percentage, absolute values are indicated in

parentheses. Statistical data processing was carried out using the Statistica 6.0 software (StatSoft, Inc.).

Results and discussion

The study of biochemical parameters of oxidative and energy metabolism revealed the development of oxidative stress in animals of the 2nd control group against the background of CTB. This was manifested in the activation of FRO in the blood (an increase in the concentration of MDA in erythrocytes by 20%, in plasma - by 11%, S index - by 42% in plasma and by 7% in erythrocytes) and a decrease in the specific activity of antioxidant enzymes (SOD, catalase, GR, Gl-6-fDH) in erythrocytes and TAA in blood plasma. A decrease in the activity of LDHpr and LDHobr by 39% and 30%, respectively, in CTB compared with intact animals led to lactic acidosis and, as a consequence, the development of hypoxia. The general dynamics of indicators of antioxidant and energy systems under the influence of course irradiation of rats with different frequency ranges under conditions of experimental burn injury is presented in the table.

Table

Dynamics of indicators of antioxidant and energy systems in groups

Biochemical indicators	Control 1 (intact)	Control 2 (CTB)	Test 3 (53.57-78.33 GHz)	Test 4 (130-170 GHz)	Test 5 (150,179-150,664)
GR, nmol NADPH/min×mg protein	89,99 ±7,10	62,03 ±5,24 *	68,88 ±2,67*	75,94 ±6,02**	80,53 ±4,39**
Gl-6-fDH, nmol NADPH/min×mg protein	42,03 ±2,11	30,23 ±1,44 *	35,90 ±2,00*/**	37,42 ±1,00*/**	39,87 ±0,68**
LDGpr, NADPH/min×mg protein	39,78 ±3,12	24,27 ±1,09*	29,55 ±0,89*/**	30,90 ±1,04*/**	32,56 ±2,00*/**
LDGobr, NADPH/min×mg protein	164,54 ±13,34	114,85 ±10,06*	128,97 ±7,53*	139,64 ±6,10*/**	147,65 ±7,48**
LPO plasma, cu	10,58±0,52	14,99 ±0,75*	12,50 ±0,68*/**	12,15 ±0,59*/**	11,43 ±0,51**
TAA, cu	0,91±0,03	0,51 ±0,02*	0,79 ±0,03*/**	0,59 ±0,02*/**	0,75 ±0,02*/**
LPO er-tes, cu	9,79±0,411	10,47 ±0,44*	7,82 ±0,33*/**	9,35 ±0,47**	6,42 ±0,32*/**
SOD, cu/mg protein	917,67 ±21,11	332,52 ±7,65*	613,35 ±14,32*/**	702,52 ±15,66*/**	648,69 ±14,98*/**

Catalase, cu/mg protein	30,24±1,01	17,56 ±0,98*	21,99 ±1,53*/**	25,38 ±1,11*/**	28,55 ±0,86**
MDA plasma, μmol/l	1,07 ±0,01	1,19 ±0,09*	0,99 ±0,02*/**	1,025 ±0,06**	1,02 ±0,07**
MDA er-tes, μmol/l	5,95 ±0,07	10,97 ±1,23*	8,79 ±0,28*/**	10,12 ±1,23*	7,96 ±1,07**

Note: * - the differences are statistically significant compared to intact rats ($p < 0.05$); ** - the differences are statistically significant compared to the CTB control ($p < 0.05$).

From the presented data, it follows that the course daily exposure to EMR THz in the ranges 130-170 GHz and 150.179-150.664 GHz on the center of autonomic regulation of animals in a state of experimental thermal injury led to a decrease in the LPO intensity in the blood plasma, most clearly expressed at the frequency of NO (by 31 %). A similar trend was characteristic of the MDA dynamics. Thus, when exposed to EMR THz 130-170 GHz, the S index remained above the control values of intact rats by 14.84% ($p = 0.001$), the concentration of MDA in erythrocytes - by 70.25%, while in animals irradiated with EMR THz with the range 150,179-150,664 GHz these indicators came to a state of physiological norm.

When exposed to radiation at NO frequencies (150.179-150.664 GHz), there was a significant increase in the specific activity of SOD, catalase, GR and Gl-6-fDH erythrocytes, as well as an increase in the level of TAA in blood plasma relative to the control (2) group by 95%, 63%. 30%, 32%, 49%, respectively. Under the influence of EMR THz with a frequency spectrum of 130-170 GHz and 150.179-150.664 GHz, the activity of SOD, TAA in the experimental groups significantly decreased compared to intact rats, the activity of GR and GL-6-fDG in the group of animals that received EMR of THz only on frequency of NO, normalized. At the same time, the erythrocytes of the blood of these animals had an increased peroxide resistance, which increased their resistance in the fight against reactive oxygen species formed against the background of thermal injury.

LPO indices in animals that received EHF EMR irradiation with a noise range of 53.57-78.33 GHz against the background of CTB demonstrated a statistically significant antioxidant effect, manifested in a significant decrease in LPO in plasma and erythrocytes (according to biochemiluminescence and MDA concentration) and an increase in TAA as well as the activity of antioxidant enzymes. Compared to intact rats, the indicators of the prooxidant system were increased, and those of the antioxidant system were decreased, which confirms the results of our previous studies [7].

Daily exposure to EMR for 7 days on burn animals led to the activation of energy metabolism in erythrocytes, which is most pronounced in the frequency range of EMR THz of nitric oxide, promoting the utilization of lactic acid. This is

apparently explained by an increase in LDH activity due to the interaction of NO with sulfate groups of the active site of this enzyme.

An important result of the study was the absence of a negative effect of all used ranges of EMP on the processes of lipid peroxidation and antioxidant protection in the experimental groups. Exposure to EMR THz with the frequency ranges MEAS of nitric oxide and oxygen, compared to EMR EHF, had a more pronounced antioxidant effect associated with an increase in TAA and enzymatic activity of SOD, catalase, GR, and Gl-6-fDH. EMP irradiation with MEAS NO had a pronounced stimulating effect on the energy metabolism of erythrocytes, manifested in the activation of LDH activity, had a normalizing effect on the enzymatic activity of FRO in the blood, the activity of GR and Gl-6-fDH.

A parallel study of MI dynamics showed that with thermal injury without subsequent irradiation (control 2), there was a statistically significant ($p < 0.05$) decrease in tissue perfusion by 21% compared to intact animals, which is natural for the pathogenesis of thermal injury. The intensity of blood flow in animals from experimental group 3 compared with rats of the 2nd control group (CTB without treatment) significantly ($p < 0.05$) increased by 29% and exceeded the normal values of animals of the 1st control group by only 11%. The greatest increase in the level of tissue perfusion was observed in rats treated with EMR THz in the ranges 130-170 GHz and 150.179-150.664 GHz. The microcirculation index turned out to be comparable in experimental groups 4 and 5, where a significant increase was recorded by 39% compared to control 1 and by 73% compared to control 2. This fact confirms the vasodilation effect of nitric oxide, which is included in both frequency ranges. To assess the mechanisms of development of adaptive vascular reactions against the background of EMR irradiation, the dynamics of factors of active and passive regulation of microcirculation was analyzed. The application of CTB affected the state of microhemodynamics, initiating the centralization of blood circulation, which was confirmed by the suppression of the local (decrease in the endothelial, neurogenic and myogenic ranges by 44%, 45% and 32%, respectively), as well as by intensive activation of the systemic (increase in respiratory by 416% and cardiac by 340% of components) regulation of microcirculation in relation to intact animals ($p < 0.05$). This trend continued in the experimental groups as well. Under the influence of EMP EHF 53.57-78.33 GHz in experimental group 3, the greatest increase in fluctuations in the ranges of endothelial (by 23%) and cardiac (by 15%) frequencies was observed in relation to the control group (2) ($p < 0.05$). In the 4th group, under the influence of EMR THz 130-170 GHz, the factors of active regulation underwent significant changes in comparison with the control (2) values (a decrease in the endothelial component by 32%, and an increase in the myogenic component - by 22%), and the factors of passive regulation increased in data of respiratory and cardiac components by 21% and

20%, respectively (p <0.05). Even more pronounced dynamics in comparison with control 2 was recorded in group 5, where the irradiation was carried out by EMR THz with a frequency of nitric oxide (150.179-150.664 GHz). This resulted in a decrease in endothelial tone by 26% and respiratory tone by 41% (p <0.05), which confirms the decisive role of NO in the development of adaptive vascular reactions. It was also noted that the systemic regulation in the 150.179-150.664 GHz group is most balanced against the background of an improvement in the venullary link, which is confirmed by a decrease in the amplitude of respiratory oscillations.

Conclusion. The results of the study allow us to expand our understanding of the degree and mechanism of the influence of various low-intensity ranges of microwave EMR on the development of protective metabolic and vascular reactions of the body, to reveal the chains of interaction of various LPO indicators, factors and components of microcirculation in the process of adaptation of the body to acute stress. The role of puncture effects on the center of autonomic regulation in vivo was confirmed. The value of nitric oxide as an endogenous vasodilator and neurotransmitter with anti-inflammatory and antitoxic effects was shown. This can form the basis of guidelines for the inclusion of microwave physiopuncture in the complex medical rehabilitation of patients with thermal trauma to provide antitoxic action and angiotrophic support for the process of reparative regeneration of connective tissue and correction of ischemic complications.

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高强度超声的动力学效应
KINETIC EFFECTS OF HIGH-INTENSITY FOCUSED ULTRASOUND

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抽象。高强度聚焦超声治疗（HIFU）已成为外科治疗的重要替代方法。   HIFU 的治疗效果基于发射器声波产生的两个过程：与受影响组织的热破坏相关的热消融，以及引发声空化和涡旋微流效应的机械位移。但是似乎尚未充分研究动力学效应。为了研究HIFU产生的机械过程，对生物学对象进行了实验研究，结果表明，超声暴露后，肝脏中糖原团的数量急剧减少，并且在其周围发现了单个散布的肿瘤细胞。肿瘤组织。因此，在生物组织中折射的声波产生机械效应，该机械效应可引起肝细胞糖原团的减少以及肿瘤细胞与母体肿瘤的分离。

关键词：高强度聚焦超声，实验，机械位移，涡旋微流，热破坏，肿瘤细胞，糖原团块。

Abstract. *High-intensity focused ultrasound therapy (HIFU) has become a serious alternative to a surgical treatment. The therapeutic effect of HIFU is based on two processes generated by the acoustic wave of the emitter: thermal ablation associated with thermal destruction of the affected tissue, and mechanical shifts that initiate the effects of acoustic cavitation and vortex microflows. But it is the kinetic effects that seem to be insufficiently studied phenomena. In order to study the mechanical processes generated by HIFU, experimental studies were carried out on biological objects, which demonstrated that after ultrasound exposure, the amount of glycogen clumps in the liver sharply decreases, and single scattered tumor cells are found on the periphery of the tumor tissue. Thus, acoustic waves refracting in biological tissues generate mechanical effects that can cause a decrease in glycogen clumps in hepatocytes and detachment of tumor cells from the maternal tumor.*

Keywords: high-intensity focused ultrasound, experiment, mechanical shifts, vortex microflows, thermal destruction, tumor cells, glycogen clumps.

Introduction

In recent years, high-intensity focused ultrasound therapy (HIFU) has become a serious alternative to surgical treatment in oncology and is actively used in the treatment of benign and malignant neoplasms of the liver, mammary glands, prostate, connective tissue, kidneys, brain and other organs [1, 2].

The HIFU method has a number of significant advantages, namely: non-invasiveness, repeatability to achieve a positive clinical effect, the absence of post-procedural changes in healthy tissues, which significantly reduces the amount of surgical and anesthetic risk [1,3]. The energy of an acoustic wave generated by a focused ultrasonic emitter, propagating in inhomogeneous biological tissues, partly turns into heat, and partly is transmitted in the form of a mechanical impulse [4].

The therapeutic effect is based on thermal destruction; the role of a mechanical impulse generating acoustic currents is practically not taken into account. But the velocity gradient in a heterogeneous biological environment can reach significant values. In particular, at a HIFU intensity of 8.2 kW / cm2 and a frequency of 1.4 MHz, the rate gradients reach $10^7 ... 10^9$ s-1 and are more than enough for rupture of cell membranes, disruption of intercellular and intracellular structures, and large molecules. Another source of mechanical microflows is pulsating cavitation bubbles. The limiting microflow velocity near the pulsating bubble can be estimated based on the equation:

$$v = U2 / \omega\alpha, \text{ where}$$
$$v \text{ - the limiting speed of the microflow;}$$
$$U \text{ - is the radial velocity of the bubble boundary;}$$
$$\omega = 2\pi f \text{ - circular frequency;}$$
$$\alpha \text{ is the average bubble radius.}$$

Considering the importance of vortex flows, the aim of the study was to analyze mechano-associated biological effects arising from HIFU-induced exposure.

Materials and methods

The objects of the study were 19 sexually mature male Wistar rats weighing 286.0 ± 3.8 g. The experiments were carried out in accordance with the "Guidelines for using laboratory animals for scientific and educational purposes at the Pavlov First Saint Petersburg State Medical University", drawn up on the basis of the Directive of the European Parliament and the Council of the European Union 2010/63/EU of September 22, 2010 on the protection animals used for scientific purposes. The animals were on unlimited consumption of standard food K-120 ("Inform-korm", Russia) and water, the light regime was changed every 12 hours.

The rats were kept in 4 rats in a plastic cage in a ventilated room at an air temperature in the range of 22–25 ° C, relative humidity - 50–70%.

The duration of the quarantine was 14 days. The animals were divided into two groups, ten of them were subcutaneously inoculated with the cell homogenate of Pliss lymphosarcoma (strain from the N.N. Petrov Research Institute of Oncology, Ministry of Health of the Russian Federation). Transplantation of a solid strain of Pliss's lymphosarcoma was performed under aseptic conditions subcutaneously in the right thigh area. A 10% suspension of cells in 0.9% sterile sodium chloride solution was introduced in a volume of 0.2 ml.

Measurement of the size of Pliss lymphosarcoma was carried out at intervals of 2-3 days within 15 days from the moment of inoculation. After the tumor reached a certain size, the animals were anesthetized by intravenous administration of Zoletil 50 (VIRBAC, France) and Xila (Interchemie werken "De Adelaar BV", Netherlands) in equal volumes at a dose of 0.5 ml / kg and placed on a thermo-statted TCAT-2 table Temperature Controller (Physitemp, USA), with constant maintenance of rectal temperature in the range of 37.0-37.8 ° C. Subsequently, the animals were exposed to high-intensity ultrasound using an N-148 S \ N 010 emitter in the following mode: frequency 1.4 MHz, intensity 8.2 kW / cm2, exposure 300 ms. The surface of the tumor was preliminarily covered with a viscous gel "Aquagel".

Another group of anesthetized animals (9 rats) performed a midline laparotomy under the control of vital functions. A rubber retractor was inserted into the operating wound and the ribs were moved to the sides, increasing the transverse size of the operating field with subsequent removal of the liver into the operating wound. Next, the most accessible surface of the liver was visually examined to exclude lesions and carry out subsequent manipulations. During preparation, the surface of the liver was constantly irrigated with a warm isotonic solution of 0.9% sodium chloride, which prevented the rapid drying of the surface of the parenchymal organ.

The selected area of HIFU irradiation in the following mode: frequency 1.4 MHz, intensity 8.2 kW per cm2 in an averaged focal spot 0.6 mm in diameter, exposure 400 ms. The zone of thermal injury was located at a depth of 1.0-1.5 mm from the liver surface. The surface of the parenchymal organ was covered with a viscous gel "Aquagel" for the passage of acoustic vibrations.

The effectiveness of ultrasonic exposure was assessed using a Seek Thermal Comhact PRO mobile thermal imaging camera for Android with micro-USB (Seek Termal, USA).

Immediately after the end of the experiment, a biopsy sample was taken from the animals near the thermal destruction and a histological study was performed. Subsequently, biopsies taken from the liver were fixed in a FAA (formalin-acetic

acid- alcohol) solution. Samples were stained with a PAS stain to detect glycogen. A significant decrease in glycogen in the liver compared to the control was noted. The sinusoidal capillaries of the liver were moderately dilated (Fig. 1).
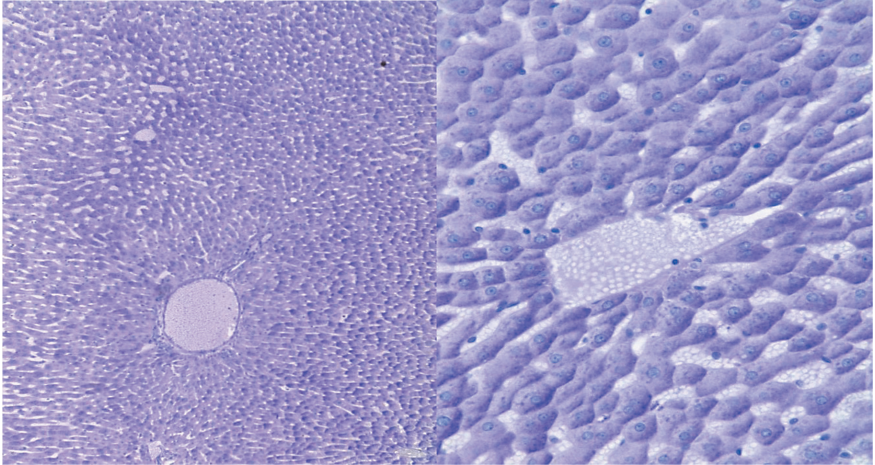
Fig. 1. *Histochemical preparation of rat liver near the zone of direct HIFU-induced exposure. PIC reaction with hematoxylin. x10 ocular, x10 objective, (a); x10 ocular, x40 objective (b).*

The study of histological preparations from tumor tissue near the focal zone by the method of light microscopy showed that the tumor is a cluster of densely located and irregular tissues with clear boundaries. The nuclei are moderately hyperchromatic and a narrow rim of highly basophilic cytoplas. In some areas, tumor cells are highly scattered, the space between them is filled with a structureless eosinophilic mass. There are separate round or oval cavities without content in the tumor tissue. In the stroma, vascular congestion, moderate edema and hemorrhage are observed. In the tissue, bundles of edematous striated muscle fibers are found, some of which are necrotic. Various types of connective tissue blood cells are represented inside the tissue. At the surface of the tumor, as well as outside it, a small number of scattered tumor cells are found in the connective tissue (Fig. 2).

a   b
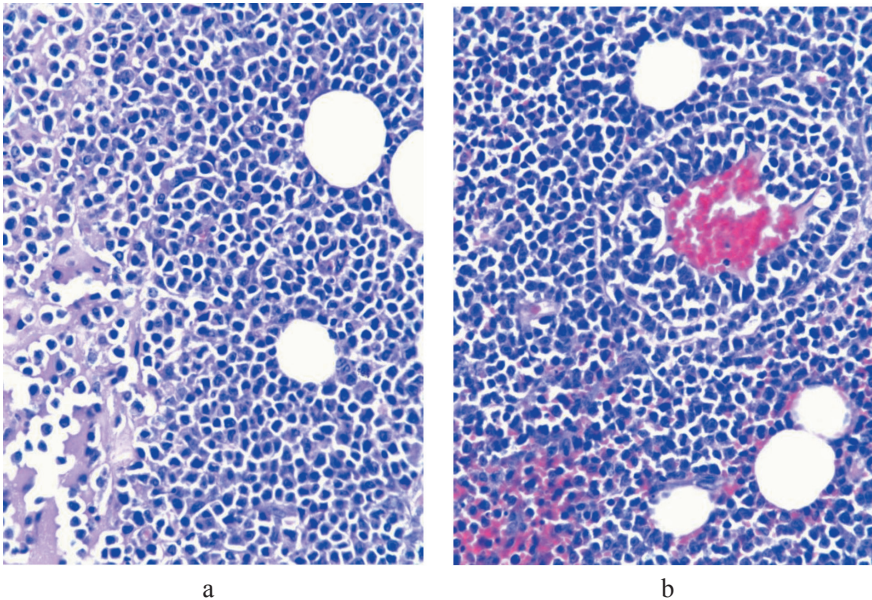
Fig. 2. Pliss transplanted lymphosarcoma after ultrasound exposure.
a - central zone, b - peripheral zone. Staining with hematoxylin and eosin. x40
objective, x10 ocular.

Discussion

A decrease in the number of glycogen granules in liver cells and scattered tumor cells outside the tumor tissue indicate the importance of ultrasonic microflows generated by high-intensity focused ultrasound.

The propagation of HIFU in heterogeneous tissues of living organisms forms acoustics in the form of a set of spatial and temporal characteristics of mechanical disturbance with the formation of interference maxima in local indices of superposition of acoustic waves from external ultrasonic and internal ones.

Conclusion

It is concluded that the response of biological structures under this influences should be determined both the nature of the energy distribution, the degree of manifestation of wave, nonlinear effects and the characteristics of a high-frequency focused acoustic field. The combined functioning of systems, organs, tissues, cells, subcellular and molecular structures generates its own acoustic field should be borne in mind. It can be assumed that the intrinsic fluctuations of biological structures are not able to form conditions for the interference of oscillations of

biostructures and an external high-frequency acoustic field. The vibrations of molecules can initiate high-frequency acoustic radiation comparable in frequency characteristics to HIFU and generate the phenomenon of superposition of acoustic waves, the role of which is also poorly studied. It is necessary that a more thorough experimental study of this phenomenon should be performed.

It should be noted that acoustic waves appear in the form of kinetic disturbances generating wave microflows that can cause mechanical changes in the cytolemma, cell membranes of tumor cells and also initiate transmembrane "breaks".

The acoustic cavitation can become a source of pressure impulses and shock waves. It is also initiated the processes of detachment of atypical cells.

Thus, the focused ultrasonic vibrations, generating an architecturally complex acoustic field in biological tissues generate thermal and mechanical effects. The reduction of glycogen clumps and detachment of atypical cells from the main tumor indicate the influence of these effects on the formation of a heat pattern and the space-time continuum of vortex microflows in the focus zone and perifocal areas.

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唾液腺的肿瘤和非肿瘤疾病的综合诊断
COMPREHENSIVE DIAGNOSTICS OF TUMORS AND NON-TUMOR DISEASES OF THE LARGE SALIVARY GLANDS

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抽象
研究目的：改进检查方法，作为复杂的术前准备工作和面部侧面病理患者的术中管理的一部分。

材料和方法。分析了俄罗斯卫生部上颌面医院FSBEI HE Pavlov FSPMU申请了手术治疗的面部侧面病理患者3年的检查，手术治疗和康复的结果。患者接受了超声检查（超声），磁共振成像（MRI），多螺旋计算机断层扫描（MSCT）；如果需要的话，进行肌钙蛋白活检–电子肌电图（ENMG）。

结论。这项工作表明需要使用MRI和IMSCT进行癌症筛查。 MRI和MSCT结果的评估有助于术前计划，并使侧面面部手术期间的术后并发症最小化。放射诊断的现代方法对于腮腺唾液腺肿瘤的复发可能的动态控制是必不可少的。 Trephine活检可简化手术计划。

关键字：唾液腺肿瘤，MRI，MSCT，钙华活检。

Abstract

Purpose of the study: *improvement of examination methods as a part of complex preoperative preparation and intraoperative management of patients with pathology of the lateral part of the face.*

Materials and methods. *The results of examination, surgical treatment and rehabilitation of patients with pathology of the lateral part of the face who applied for surgical treatment to the maxillofacial hospital FSBEI HE Pavlov FSPMU of the Ministry of Health of Russia for 3 years were analyzed. The patients underwent sonography (ultrasound), magnetic resonance imaging (MRI), multispiral com-*

puted tomography (MSCT); trephine biopsy, if indicated - electroneuromyography (ENMG).

Conclusion. The work indicates the need for the use of MRI and MSCT for cancer screening. Evaluation of MRI and MSCT results facilitates preoperative planning and minimizes postoperative complications during lateral facial surgery. Modern methods of radiological diagnostics are indispensable for dynamic control of possible recurrence of tumors of the parotid salivary glands. Trephine biopsy makes it easier to plan the operation.

Keywords: salivary gland tumors, MRI, MSCT, trephine biopsy.

Introduction. Diseases of the parotid and submandibular salivary glands are quite common in the clinical practice of the maxillofacial surgeon. Diagnostics and surgical treatment of tumors and non-tumor diseases of the large salivary glands were made more difficult by 1) unwillingness of patients to contact a surgeon; 2) insufficient information content of standard methods for diagnosing volumetric formations of soft tissues used at the primary stage of diagnosis; 3) inaccuracy of the results of a cytological study (material for which is obtained by conducting a fine-needle aspiration biopsy).

The importance of in-depth diagnostics of diseases of the lateral facial soft tissues is confirmed by many authors [1-4, 6]. In addition, the results of multicenter studies on the application of the method of biopsy of salivary gland tissues with a thick needle ("core-needle biopsy") have been actively published in foreign scientific literature over the past 20 years [7-12], while in the domestic literature available to us there are references to the use of this method in relation to the diagnosis of diseases of the large salivary glands.

Purpose of the study: improving the quality of complex diagnostics of tumors and non-tumor diseases of the large salivary glands.

Tasks of the study:

1) improvement of radiation examination methods as part of a complex preoperative preparation of patients with tumors of the parotid salivary gland.

2) assessment of the significance of the method for obtaining biological material in diseases of the salivary glands of a tumor and non-tumor nature using a semi-automatic needle for soft tissue biopsy (trephine biopsy).

Materials and methods. An open prospective non-randomized study of 97 case histories of patients with lateral facial pathology (tumors of the salivary glands and paralysis of the facial muscles) who were treated at the FSBEI HE Pavlov FSPMU Oral and Maxillofacial Surgery Clinic of the Ministry of Health of Russia from January 2015 to December 2017 was performed. using the package of licensed programs for statistical data processing "Statistica" (version 10).

The obtained information (including age, sex, tumor localization, the nature of

surgical treatment, the result of histological examination, the presence of postoperative dysfunction of the mimic muscles) were entered into the original computer program "Planning and accounting of dispensary observation after surgical treatment of patients with parotid pathology. salivary glands and paralysis of facial muscles "(certificate of state registration № 2016661620 dated October 14, 2016). The data was analyzed using descriptive statistics. After obtaining voluntary informed consent, photographing and video filming of patients were carried out before, during and after the operation.

All examined patients underwent:

1. Ultrasound examination of the salivary glands, facial nerve and lymph nodes of the neck was performed at the Federal State Budgetary Institution Children's Research and Clinical Center for Infectious Diseases of the Federal Medical and Biological Agency (Cand. of Med. Sci. Klimkin A.V.) on a General Electric apparatus, LOGIQ E9 with the analysis of the acoustic properties of the scanned area using the "post-processing" image enhancement algorithm. The study was carried out in real time on the "healthy" and "affected" sides. The integrity of the facial nerve was assessed, its diameter was measured at the level of the exit from the styloid foramen and / or in the salivary gland before surgery.

2. Magnetic resonance imaging (MRI) of the parotid, submandibular regions and soft tissues of the neck was performed at the X-ray computed tomography department № 2 of the FSBEI HE Pavlov FSPMU of the Ministry of Health of Russia (Cand. of Med. Sci. Bubnova E.V.) on a high-field magnetic resonance tomograph (with a magnetic field strength of 1.5 Tesla) from General Electric (GE) in coronal, axial and sagittal planes using T1 and T2 pulse sequences (PS), as well as programs with fat suppression (selective and non-selective), a special pulse sequence DWI (with b = 0.100 and MCD mapping) and contrast enhancement (including the use of the subtraction technique (image subtraction).

3. Multispiral computed tomography (MSCT) of the maxillofacial region and the lateral surface of the neck was performed at the X-ray computed tomography department № 1 of the FSBEI HE Pavlov FSPMU of the Ministry of Health of Russia, followed by CT angiography and imaging reformation (MPR, VRT).

Trepan biopsies were performed in 27 patients with tumor and non-tumor diseases of the large salivary glands. To obtain tissue biopsy, an ultra-light semi-automatic needle for soft tissue biopsy "Light-Cut" (LLC "Aktimed Plus") was used, including a stylet with a pyramidal tip (sharpening of the "trocar" type) in a set with a coaxial needle (introducer). The tissue sample was taken under sonographic control, confirming the penetration of the instrument into the area of interest. The needle was brought to the loaded position, after the first descent, the stylet was extended, and the cannula was lowered with the second movement. The material was extracted in the form of a "column" and subsequently, according to

the standard technique, was fixed in 10% neutral formalin. The resulting material was processed in the pathological laboratory according to the biopsy protocol, and not according to the protocol for processing the surgical material.

Research results and their discussion. The results of treatment of 97 patients with tumors of the parotid salivary glands (94 people) and persistent paralysis of the facial muscles (3 people) who applied for surgical treatment to the FSBEI HE Pavlov FSPMU Clinic of Maxillofacial Surgery of the Ministry of Health of Russia from January 2015 to December 2017 were analyzed. It should be noted, that despite the existence of a license to treat cancer patients with malignant processes, in most cases, patients with benign neoplasms of the parotid salivary glands were selected for hospitalization.

In total, of the entire sample of patients, men accounted for 26% (25 people), and women - 74% (71 people). The average age of patients in 2015 was 50 years and 6 months, in 2016 - 49 years, in 2017 - 50 years. The annual prevalence of patients who initially applied for treatment was noted. In general, for the specified period, the ratio of men and women can be represented as 1: 2.8. The prevalence of the female part of the population in the structure of primary patients was noted annually. For 3 analyzed years, no significant fluctuations in the number of case patients were noted. Out of 94 patients with neoplasms of the parotid salivary glands, benign tumors were diagnosed in 90.4% (85 people); malignant in 9.6% (9 people) (tumor ratio: 9.4: 1). As part of the work performed, it was revealed that among the patients seeking surgical treatment in the maxillofacial hospital of the FSBEI HE Pavlov FSPMU of the Ministry of Health of the Russian Federation for 3 years, patients suffering from benign neoplasms of the parotid salivary glands prevail every year. The overwhelming majority of malignant tumors were unexpected findings after the final histological examination and were interpreted as the result of malignancy of the primary benign tumor. It should be noted that our data do not contradict the global statistics. According to the analysis of the results of the postoperative histological report, pleomorphic adenoma is the most common among benign neoplasms of the parotid salivary glands, followed by adenolymphoma. Among all the noted patients with tumors of the parotid salivary glands from 2015 to 2017, thanks to the timely MRI monitoring, 2 cases of recurrence of tumors of the parotid salivary glands were detected at early stages. These patients were previously operated at the Pavlov FSPMU Oral and Maxillofacial Surgery Clinic. In one case, after block resection in 2013 (after 2 previous operations in other medical institutions), a recurrent formation of a tumor node of the salivary gland (histologically - adenoma) was revealed 4 years after the last intervention (in 2017). In another case, 10 years after the first operation, a relapse of the neoplasm with malignancy of the process was revealed. I would like to draw special attention to the fact that the rest of the patients registered in the medical electronic

database as patients with recurrent neoplasms of the parotid salivary glands were sent for high-tech treatment from other regions, where they received primary treatment.

After clinical examination, the patients underwent ultrasound and / or contrast-enhanced magnetic resonance imaging of the parotid regions and neck. Only then was a fine-needle aspiration biopsy performed to verify the diagnosis.

Ultrasound of the parotid regions and the facial nerve is characterized by convenience, simplicity and speed. The high value for the maxillofacial surgeon and oncologist of the information obtained by ultrasound of the facial nerve should be noted [5]. In the present study, the integrity of the facial nerve was assessed, its diameter was measured at the level of the exit from the styloid foramen and/or in the salivary gland in the preoperative period. This helped to facilitate the planning of surgery and reduced the risk of accidental injury to neural structures. In addition, ultrasound facilitates objective control in the postoperative period for the regeneration processes (during neuroreconstructive procedures). To date, among all non-invasive imaging procedures for the extratemporal part of the facial nerve, ultrasound with an analysis of the acoustic properties of the scanned area using a "post-processing" image enhancement algorithm has no comparable analogues in terms of diagnostic significance. However, given that ultrasound is an "operator-dependent" method, it should be recognized that the absolute priority in tumor imaging belongs to MRI and MSCT.

At the present stage of complex diagnostics, MRI allows you to assess the shape and size of both the salivary gland and the tumor; clarify the localization and internal structure of the neoplasm; to draw the boundaries between the tumor and the unchanged gland tissue, including determining the presence of invasion into the adjacent tissues, which allows us to conclude about the degree of malignancy of the process [10].

When carrying out this scientific and practical work, radiologists at the preoperative stage using MRI assessed the location of the salivary glands, their size, contours, and structure homogeneity. When areas with abnormal magnetic resonance signal were identified in the structure of the salivary gland, "thin slices" were performed on the area of interest; programs with fat suppression and post-contrast subtraction technique were used. With the participation of maxillofacial surgeons, the depth of the tumor in the tissues of the salivary gland was assessed, which, in turn, suggested its relationship with the trunk and branches of the facial nerve. This reduced the risk of iatrogenic injury to nerve structures, and also made it possible to predict the likelihood of a microsurgical stage of surgery. During the interpretation of the data obtained, the location of the cisternal and intratemporal parts of the facial nerve was assessed; an attempt was also made to visualize its peripheral branches. Computed tomography of the salivary glands was performed

in the course of a complex multispiral computed tomography of the maxillofacial region and the lateral surface of the neck [6]. MSCT made it possible to clarify the localization of the neoplasm in relation to the bone structures of the skull base, which are invariable landmarks for searching for the facial nerve trunk. The nature of growth of neoplasms and the extent of tumor infiltration were assessed. In some cases, computed tomographic angiography was additionally performed with the construction of volumetric image reformation. It should be noted that MSCT clearly diagnoses the presence of mineralized calculi in the salivary glands; their number, location, size and shape.

Taking into account the repeated discrepancy in the diagnosis between the results of the cytological examination before the operation and the histological examination, it was decided to conduct a histological examination before the operation. For this purpose, 27 patients underwent 27 trephine biopsies of the large salivary glands. Biopsy for tumors of the large salivary glands was performed in 20 cases, in connection with non-neoplastic and degenerative changes in the large salivary glands - in 7 cases. The analysis of the results of pathomorphological examination of biopsy specimens of the large salivary glands revealed the following: in 25 cases out of 27 (92.6%), the preoperative diagnosis coincided with the results of postoperative histological examination. In 2 cases out of 27 (7.4%), the diagnostic material turned out to be uninformative, which can be explained by technical errors in the development of the technique at the beginning of the study. Benign tumors of the parotid salivary glands included adenolymphoma (Worthin's tumor), oncocytoma, and pleomorphic adenoma (mixed cell tumor). Among non-neoplastic diseases of the large salivary glands, chronic sialoadenitis and such a rare disease as sclerosing polycystic adenosis were diagnosed. It should be noted that the volume of material obtained during trephine biopsy allows for modern additional morphological studies, including immunohistochemistry (Ki-67 is a proliferation marker, E-cadherin is an adhesion marker, a wide range of antibodies to cytokeratins and basal cells - p63, etc.)

Later, in a number of patients, the obtained MSCT and MRI data were applied intraoperatively by combining an electromagnetic navigation surgical station in the base, which made it possible to accurately determine the main landmarks of the exit site of the facial nerve trunk from the facial nerve canal (styloid process and styloid opening of the temporal bone). This was used to reduce the likelihood of accidental trauma to the facial nerve trunk under conditions of a typical anatomical structure altered by the tumor process.

After isolating the trunk of the facial nerve, the subsequent oncological stage of the operation was carried out under the control of intraoperative neuromonitoring, which made it possible to quickly and minimally traumatically remove the neoplasm without violating the integrity of the facial nerve. In all cases where the

facial nerve was involved in the tumor process, it was transected with simultaneous neuroplasty.

In the postoperative period, patients with paralysis/paresis of mimic muscles received an individually selected course of conservative therapy, performed taping and engaged in physiotherapy exercises. Evaluation of the results of neuroplasty showed that all patients with facial paralysis managed to obtain acceptable, good, and excellent results according to the M. May scale.

Conclusion:

1. The conducted statistical analysis of the case histories of patients with tumors of the parotid salivary glands, who were treated at FSBEI HE Pavlov FSPMU of the Ministry of Health of Russia, indicates the need to strengthen measures to identify this pathology in patients of working age for early surgical care and increase the percentage of cured patients.

4. Evaluation of the results of MRI and MSCT performed in patients with tumors of the large salivary glands allows for reliable and accurate visualization of anatomical structures, which helps in making a preoperative ("working") diagnosis and allows for a preliminary non-invasive assessment of the degree of tumor penetration into adjacent tissues.

5. Preoperative evaluation of the data of magnetic resonance imaging and multispiral computed tomography (in the presence of tumors in the large salivary glands) facilitates preoperative planning (assessment of the volume of removed tissues and the likelihood of performing the microsurgical stage of the operation).

6. MRI and MSCT data, combined in modern devices for surgical navigation, can be used intraoperatively when performing block resections in the deep parts of the lateral region of the face, which minimizes complications and improves the result of surgical intervention.

7. Performing magnetic resonance imaging and multispiral computed tomography in patients with malignant tumors of the large salivary glands is an integral component when planning the layout for radiation therapy in the postoperative period, or when conducting palliative therapy in incurable patients.

8. In patients who have undergone surgery for tumors of the large salivary glands, it is recommended to carry out dynamic control using modern methods of radiation diagnostics (MRI and / or MSCT) to detect possible neoplasm relapses or malignant tumor metastases at early stages.

9. This work demonstrates the first experience of using a semi-automatic needle for soft tissue biopsy in diseases of the large salivary glands in patients of the FSBEI HE Pavlov FSPMU clinic of the Russian Ministry of Health. The analysis shows that the quality and quantity of material obtained from the tissues of the large salivary glands in most studies was regarded by pathologists as adequate and suitable for the primary diagnosis. Trepan - biopsy using this technique is mini-

mally invasive, which is extremely important for interventions in the maxillofacial region. The terms of work of morphologists were reduced by almost 2 times, compared with incisional biopsy. Thus, highly accurate, fast and minimally traumatic preoperative diagnosis verification allows the maxillofacial surgeon to optimize patient routing and facilitate surgery planning. Considering the above, we recommend using a semi-automatic soft tissue biopsy needle for the initial diagnosis of tumors and non-neoplastic diseases of the large salivary glands.

Based on the research work carried out, we formulated the following *practical recommendations*:

1. The ultrasound method of research is *recommended* for screening groups of clinically asymptomatic individuals in order to detect pathology of the lateral part of the face (in particular, to detect tumors of the parotid salivary glands).

2. When examining patients with benign tumors of the large salivary glands, it is *recommended* to perform MRI on a high-field magnetic resonance imager (with a magnetic field strength of 1.5 Tesla) in the coronal, axial and sagittal planes, using T1 and T2 pulse sequences, as well as programs with fat suppression, PS DWI and contrast enhancement.

2. When examining patients with malignant tumors of the large salivary glands, MSCT is *recommended*, followed by CT angiography and the construction of planar and volumetric image reformation (MPR, VRT).

3. CT-angiography is *recommended* for non-invasive assessment of the degree of tumor vascularization and its relationship with the carotid vessels.

4. Fine-needle aspiration biopsy of salivary gland tumors *should be performed* strictly after MRI, due to the presence of a hemorrhagic component after puncture.

5. It is *recommended* to perform trephine biopsy using specialized instruments to verify the diagnosis in tumor and non-tumor diseases of the large salivary glands.

6. Ultrasound of the facial nerve in the preoperative period is *recommended* for the initial assessment of the ratio of the tumor to the structures of the facial nerve.

7. When planning extended oncological operations, incl. with neuroplasty of the facial nerve, it is *recommended* to use intraoperative navigation based on previously obtained MRI and CT data of the maxillofacial region.

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建立后生动物标本老化特性的方法之一
ONE OF THE WAYS OF THE ESTABLISHMENT OF THE AGING PROPERTY IN METAZOA SPECIMEN

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抽象。 本文基于模块化和单一后生动物的生存策略的比较。 在进化过程中发生的个体结构复杂化，降低了其细胞重新分化的能力。 因此，已经失去了个人的祖先特性，以防止其衰老并被大多数当前存在的后生动物无性繁殖。 这种损失是他们发展的转折点。 它加速了它的发展，从而提高了人们对环境变化的适应能力。
关键词：模块化动物适应性进化

Abstract. *The article is based on the comparison of the life strategy of modular and unitary Metazoa. The complication of the structure of an individual, which occurred in the course of evolution, reduced the ability of its cells to re-differentiate. Because of this, the ancestral properties of the individual to prevent aging and reproduce asexually by most of the currently existing Metazoa species have been lost. This loss is a turning point in their evolution. It accelerated it and thereby increased the adaptability of populations to environmental changes.*

Keywords: *modular animals, adaptability, evolution.*

In species close to the base of the evolutionary ladder of Metazoa, anti-aging processes take place in the body. These species are capable of asexual reproduction. The purpose of this article is to discuss how the rate of evolution and the adaptability of populations was influenced by the loss of potential immortality and the ability to reproduce asexually by most Metazoa.

In the course of evolution, the possibilities of preventing aging changes in the body have narrowed.

Metazoa are divided into modular and unitary. Modular are those that reproduce sexually and asexually, unitary - only sexually. With asexual, an individual is formed from a complex of somatic cells or from a part of the individual's body. A module of a modular animal is an individual formed by asexual reproduction, genetically identical to the parent. Modular animals are divided into two groups. In representatives of the first, the modules are not separated from the parent, but retain a physiological connection with it. These are sponges, hydroid and coral polyps, bryozoans, intra-powdery and colonial ascidians. In the representatives of the second group, the modules formed by asexual reproduction lead an independent life. Representatives of the second group are found among ctenophores, turbellaria, nemerteans, annelids, and echinoderms [5]. Some of these freely mobile invertebrates reproduce only sexually, that is, they are already unitary.

Any newly emerging system (of an organismic, supraorganic level, or multispecies) is at first simple. The number of functionally different elements in it is small and these elements are not very specialized. In the course of evolution, given the presence of underutilized energy resources in the environment and the possibility of their use, the number of functionally different elements in the system grows, the elements become more and more specialized, and the dependence of its parts on the whole increases. This allows the system to make better use of the resources of the environment. As power consumption increases, the energy flow through the system is increasing. Its power-to-weight ratio is also increasing. And the greater the power-to-weight ratio of the system, the more chances it has to survive in the struggle for existence and not be weeded out by natural selection [1, 8, 11].

The evolution of a Metazoa individual - is a special case of the evolution of biosystems. In an individual, in the course of evolution, the number of functionally different cells increased, the cells became more and more differentiated. This allowed it to make fuller use of the energy resources of the environment and, therefore, its power supply increased. An increase in the power-to-weight ratio gave an individual an advantage in the struggle for existence over less power-equipped individuals [2-4].

There is an assumption that the first Metazoa on Earth were sedentary and modular [6, 15, 16, etc.]. In modern sessile modular invertebrates, the number of functionally different cells in the body and their differentiation are the smallest in comparison with other animals. Only in them, due to the low differentiation of cells, derivatives of one germ layer can be converted into derivatives of another [5]. In freely mobile modular species, the number of functionally different cells in the body and their differentiation is greater. The number of functionally different

cells in the body and their differentiation in unitary species are even greater. If the authors are right who believe that the first Metazoa on Earth were sedentary and modular, then the evolution of Metazoa is the transformation of the first sedentary modular species on Earth, first into freely movable modular, and then into unitary. At the same time, the differentiation of cells and the complexity of the structure of the individual grew, and its power-to-weight ratio became more and more.

In individuals of unitary species, ontogeny is irreversible. They die not only from external causes, but also from internal ones - from an endogenous decrease in homeostatic properties, that is, from aging. In contrast to the unitary species, the ontogeny is reversible in individuals of many modular species. They do not die of old age. Let us compare the ways in which sedentary and free-moving modular species avoid aging. They are most diverse in sessile modular invertebrates. Their individual is a colony. The first way they avoid senile changes is the transition to embryonic diapause. Adult modules dissolve during this transition, and the material of which they are composed serves to build diapausing somatic embryos. In sponges, they are called gemmules, in eaters - podocysts, in bryozoans - statoblasts, in intra-powdery and colonial ascidians - resting buds. Sponge gemmules are similar to morula, somatic diapausing embryos of other sessile modular invertebrates - with blastula or gastrula [5]. The formation of diapausing somatic embryos in sedentary modular species is the return of an individual to an embryonic state. The second way is reduction. Reduction leads to a decrease in the size of modules, death and/or dedifferentiation of all its differentiated cells. Upon reduction, the modules turn into reduction bodies similar in structure to early embryos [5]. Reduction is also the return of an individual to an embryonic state. The third way is to update the modular composition of the colony. The lifespan of modules in modular individuals is limited. One is replaced by another. Thanks to the update, the old modular specimen consists of young modules. The presence of these three methods of preventing aging in a sedentary modular individual makes it potentially immortal [12, 13, 17]. Some coral colonies are hundreds of thousands of years old [13].

Freely mobile modular invertebrates have fewer ways to avoid old age. They, unlike sedentary ones, age. Aging in them begins after several acts of asexual reproduction [5]. Some of them (turbellaria and nemerteans) can reversibly return to the embryonic state, but only by reduction [5]. They are not capable of forming diapausing somatic embryos. Thus, in the course of evolution, Metazoa showed a decrease in its ability to prevent senile changes in the body.

The decline in an individual's ability to prevent aging – is the result of natural selection.

The lower the cells of the body are differentiated, the more pronounced their ability to re-differentiate. In sedentary modular invertebrates (and only in them), as mentioned above, derivatives of one germ layer can be converted into derivatives of another. Their cells are the least differentiated among Metazoa. The formation of diapausing somatic embryos and reduction bodies, as well as embryos of new modules during the renewal of the modular composition of a sedentary modular individual, begins with cell dedifferentiation. In the course of its cells, specialization is lost. After this dedifferentiation, cells differentiate in new directions [5]. Consequently, the high ability of their cells to re-differentiate allows sedentary modular species to prevent the appearance of senile changes in the body. Freely movable modular species prevent the appearance of senile changes in the body (by means of reduction) also allows the ability to re-differentiate.

As a result of natural selection, the structure of the organism became more complicated, the number of functionally different cells in it, that is, their differentiation, increased, and the ability of cells to re-differentiate was weakened because of this. The decrease in the ability of cells to redifferentiate led to the fact that the individual's ability to prevent aging decreased. This led Metazoa to lose its ability to prevent aging, that is, to the emergence of unitary species.

The growth of differentiation of the cells of the body of an individual, which took place in the course of evolution, also led to the fact that its most highly differentiated cells, due to the loss of the ability to reproduce, became non-renewable. They also became non-renewable due to a decrease in the cells' ability to differentiate. Non-renewable cells play a key role in maintaining the body's homeostasis. But due to the second law of thermodynamics, sooner or later, but necessarily, they are destroyed. Their loss is senile involution. It reduces the homeostatic properties of the individual and its death becomes inevitable because of this decrease. Thus, aging is the result of not active suicide, as V.P. Skulachev [9, 10] proposes, but a passive consequence of the fact that the cells of an individual lack the ability to re-differentiate and therefore cannot compensate for the death of non-renewable cells by forming new ones instead.

From the above, it follows that only species that are close to the base of the Metazoa phylogenetic ladder do not age, and that all unitary species age. But it is widely believed that individuals of some unitary species are potentially immortal. So, V.P. Skulachev [9] writes that sea urchin, large crabs, pearl mussel, pike, shark, sea bass, toad, giant turtle, crocodile, raven, albatross, whale, naked mole rat and bat do not age. The reason for classifying these unitary animals as ageless is that they were not observed for a long time.

The loss of the ability to prevent senile changes in the body and reproduce asexually has accelerated evolution.

With asexual reproduction, a part of an individual's body gives rise to another or other individuals. In relation to a modular animal, sedentary and freely moving, the term "individual" (indivisible) is inapplicable. The term "geneta" is used instead. Geneta - is a collection of modules that have arisen from one zygote. It can be represented by one or many modular individuals [14]. All geneta modules are genetically identical to each other. Genetic diversity in populations of asexually modular species is therefore low. In the absence of sexual reproduction in the population, and in some populations this occurs [5]. A population may even consist of one geneta. The possibilities of natural selection (and the rate of evolution) are the higher, the greater the genetic diversity in the population.

Cell re-differentiation is necessary not only for the rejuvenation of the individual, but also for its asexual reproduction. Natural selection, aimed at complicating the individual, led to the loss of the cells' ability to re-differentiate, and in the individual - to the loss of the ability to reproduce asexually. Unitary species began to use a more efficient strategy of adaptation to the environment than their modular ancestors. Due to the loss of the ability for asexual reproduction, that is, for copying genotypes, the possibilities of selecting and screening out genotypes have increased. And this accelerated evolution and, consequently, increased the adaptability of the population. Its adaptability was also increased by the fact that, due to the loss in individuals of the ability to prevent senile changes, the change of genotypes accelerated in populations. The price of the increased adaptability of the population is the loss of potential immortality in individuals. But to maintain the reliability of the existence of a species, the ability of a population to reorganize genetically in response to changes in the environment with the help of natural selection is more useful than the potential immortality of individuals.

The acceleration of evolution, which occurred due to the loss of the ability to reproduce asexually, also accelerated the adaptive radiation of species. One of the reasons for the outbreak of species diversity that occurred shortly before the Cambrian may have been the loss of the ability of Metazoa to reproduce asexually at that time. Many Metazoa, which took the path of refusal to increase the differentiation of cells, did not die out, but survived and evolve. But they stand on the sidelines of the main path of development of life on Earth. Most of the species of the World Ocean, freshwater and land are unitary. The sharp prevalence of the number of unitary species over modular indicates that the emergence of unitarity is an aromorphosis, a progressive evolutionary change in the structure, leading to a general increase in the level of organization of the organism and an increase in its power-to-weight ratio. The emergence of unitarity in Metazoa is a turning point in evolution. Unitarity provided an evolutionary advantage in the struggle

for existence in any environmental conditions, since it increased the adaptability of populations. A freely movable modular individual also has the property of aging. But after its death, there are descendants genetically identical to her, formed by asexual reproduction. The death of a freely mobile modular individual from old age does not accelerate the replacement of some genotypes with others, does not facilitate the genetic restructuring of the population to the changed environment and does not accelerate evolution.

The life strategy of plants is similar to the life strategy of sessile modular invertebrates [7]. Plant shoots are their modules. In plants, as in sessile modular invertebrates, somatic resting embryos - resting buds - serve to experience an unfavorable period for life. They are formed in trees and shrubs on the branches, in herbaceous plants - on rhizomes, roots, tubers. The bulb is a dormant bud. Resting plant buds and diapausing somatic embryos of sessile modular invertebrates are similar formations. The formation of dormant buds in plants is the return of the organism to the passed stage of development, its rejuvenation.

Plants can form dormant buds due to the high ability of cells to re-differentiate, and their cells have this ability because they are poorly differentiated. Due to the ability of cells to redifferentiate, plants also have the ability to reproduce asexually. Plants did not reach the critical stage discussed in the article during their evolution.

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利用生物指示方法研究郊区生态系统的技术污染
RESEARCH OF TECHNOGENIC POLLUTION OF SUBURBAN ECOSYSTEMS USING THE BIOINDICATION METHOD

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该研究调查了在苏格兰克拉斯诺亚尔斯克郊区使用苏格兰松树和西伯利亚云杉作为生态系统状态的生物指标的可能性。 所获得的数据可用于评估森林生态系统的污染水平。
关键词: 樟子松西伯利亚云杉生物指示重金属
The study investigated the possibility of using Scots pine and Siberian spruce as a bioindicators of the ecosystem state in the suburb of Krasnoyarsk. The obtained data can serve to assess the pollution level of forest ecosystems.
***Key words:** Scots pine, Siberian spruce, bioindication, heavy metals*

Introduction. The chemical composition of plants often reflects the elemental composition of soils. Therefore, excessive accumulation of heavy metals by plants is primarily due to their high concentrations in soils. However, their ability to bind and concentrate heavy metals has its limits.

The mechanisms of plant resistance to excess heavy metals can manifest themselves in different ways: some species are able to accumulate high concentrations of heavy metals, but show tolerance to them; others seek to reduce their admission by maximizing their barrier functions. For most plants, the first barrier level is the roots, where the largest amount of heavy metals is retained and the second, stems and leaves and other plant organs responsible for reproduction (often seeds and fruits, as well as tubers).

However, these patterns are not always repeated, which is probably due to the growing conditions of plants and their genetic characteristics. There are cases

when different varieties of the same crop growing on equally polluted soil contained different amounts of heavy metals [1].

This fact, apparently, is due to the intraspecific polymorphism inherent in all living organisms, which can also manifest itself in man-made pollution of environment. This property in plants can become the basis of genetic and selection studies in order to create new varieties with increased protective capabilities against excessive concentrations of metals. Despite the significant variability of different plants to heavy metals accumulation, bioaccumulation of elements has a certain tendency, which allows you to organize them into several groups: the first - Cd, Cs, Rb are elements of intensive absorption; the second - Zn, Mo, Cu, Pb, As, Co are medium absorption; the third - Mn, Ni, Cr are weak absorption; and the fouth - Se, Fe, Ba, Te are difficult to reach plants. Coniferous plants, in particular Scots pine and Siberian spruce, also have these functions [2].

Another way of intaking heavy metals in plants is non-root absorption from the air stream. It happens when significant influx of metals from the atmosphere on the sheet surface, especially near large industrial enterprises. The entry of elements into plants through the leaves (or foliar absorption) occurs mainly by non-metabolic penetration through the cuticle. In this case, heavy metals can be transferred to other organs and tissues and included in the metabolism [3].

The purpose of the study is the possibility of using Scots pine and Siberian spruce as a bioindicators of the ecosystem state in the suburbs of Krasnoyarsk.

The assimilation apparatus of Scots pine and Siberian spruce was used as the object of research. Sampling was carried out in the settlement Berezovka, near the Minino village, in the National Park "Stolby", as a background used samples taken 50 kilometers from the city at the Kacha station. Samples were taken in the spring and autumn of 2019 from young at least 10 trees in a height of 1.3 meters from the ground. The ash was examined for the presence of heavy metals using the spectrometric method on the SPECTROSCAN device [4]. The concentration of heavy metals in the sample was determined by the intensity of the analytical lines and comparing them with the reference. The scheme of needles sampling is shown in figure 1.
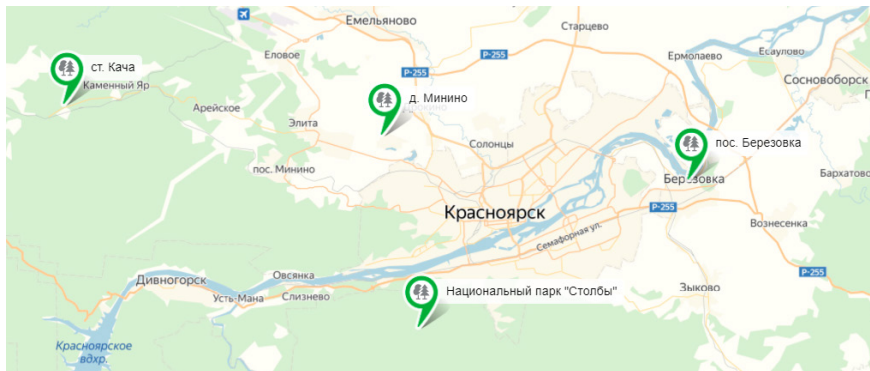
***Figure 1** – Sampling scheme of needles*

The resceived dose of aerogenic pollutants can cause acute changes in metabolism in the assimilation apparatus, which can be observed for a short time in the appearance of chlorosis, necrosis and premature fall of needles. At the same time, low concentrations of pollutants with prolonged exposure can be detected during morphometric measurements of needles, as well as visual analysis of the general condition of stands and identification of sparseness and dryness of their crowns and can be characterized by cumulative damage. The most informative data are obtained by analyzing the characteristics of needles, which allow fast, relatively reliable and without additional tools to make an approximate idea about environmental situation in the study area. Data of morphometric measurements of pine and spruce needles are presented in table 1.

Table 1

Indicators of the arithmetic mean length of Scots pine and Siberian spruce two-year-old needles, millimeters

Sampling area	Siberian spruce		Scots Pine	
	spring	autumn	spring	autumn
The Minino village	1,6±0,3	2,1±0,3	4,9±0,4	5,1±0,4
The National Park "Stolby"	2,2±0,4	2,9±0,4	5,3±0,3	6,2±0,3
The settlement Berezovka	1,4±0,1	1,9±0,3	4,7±0,45	4,9±0,4
The Kacha station (background)	2,4±0,2	3,1±0,2	7,1±0,5	7,3±0,5

It was found that the maximum length of pine and spruce needles is typical for background plantings. According to the analysis of the obtained data, the deviation of the length of Siberian spruce needles from the background in the settlement Berezivka is 42% in spring and 39% in autumn, in the Minino village - 33% in spring and 32% in autumn and in the National Park " Stolby"– 8% and 6% re-

spectively. The results of research the heavy metals concentration in pine spruce needles are presented in table 2 and 3 accordingly.

Table 2

The content of heavy metals in the needles of Scot Pine, mg/kg, winter/spring/summer

Element	The concentration of metal in pine needles, mg/kg			
	The Minino village	The National Park "Stolby"	The settlement Berezovka	The Kacha station (background)
Fe	43,03±0,3 40,29±0,2 29,67±0,1	38,56±0,4 35,89±0,5 23,77±0,2	40,97±0,5 37,29±0,1 25,69±0,2	37,45±0,2 34,65±0,3 20,15±0,6
Zn	21,87±0,3 18,88±0,2 13,45±0,3	24,35±0,3 20,56±0,2 13,60±0,5	24,98±0,4 21,02±0,3 11,14±0,5	10,21±0,2 9,45±0,5 7,18±0,6
Cu	2,04±0,2 1,82±0,3 2,12±0,5	0,793±0,3 0,767±0,2 0,750±0,4	2,06±0,3 1,56±0,5 0,76±0,15	0,923±0,2 0,619±0,3 0,290±0,4
Mn	2,98±0,4 2,45±0,3 1,08±0,4	0,265±0,4 0,196±0,5 0,105±0,25	0,455±0,3 0,344±0,2 0,194±0,3	0,145±0,3 0,090±0,3 0,087±0,4

According to table 2, the largest amount of heavy metals is observed in winter in the needles of Scot Pine near the Minino village, slightly less in the settlement Berezovka and at least at the Kacha station (background). A similar pattern is observed for spruce needles (table 3). These data are in good agreement with the results obtained earlier [5].

Table 3

Heavy metal content in Siberian spruce needles, mg / kg, winter/spring/summer

Element	The concentration of metal in pine needles, mg/kg			
	The Minino village	The National Park "Stolby"	The settlement Berezovka	The Kacha station (background)
Fe	39,23±0,3 37,04±0,2 25,57±0,1	28,44±0,4 25,85±0,5 22,74±0,2	39,97±0,5 38,29±0,1 25,69±0,2	25,56±0,2 22,45±0,3 18,85±0,6
Zn	19,47±0,3 14,78±0,2 11,23±0,3	22,39±0,3 17,16±0,2 10,65±0,5	23,98±0,4 20,02±0,3 12,64±0,5	9,21±0,2 7,85±0,5 5,78±0,6
Cu	1,97±0,2 1,43±0,3 1,12±0,5	0,693±0,3 0,667±0,2 0,650±0,4	1,96±0,3 1,46±0,5 0,56±0,15	0,813±0,2 0,534±0,3 0,199±0,4
Mn	2,18±0,4 2,15±0,3 1,54±0,4	0,215±0,4 0,146±0,5 0,113±0,25	0,755±0,3 0,574±0,2 0,364±0,3	0,125±0,3 0,079±0,3 0,063±0,4

According to the presented data, the needles of Scots pine and Siberian spruce accumulate a certain amount of heavy metals in their biomass, which come with atmospheric emissions from anthropogenic sources, including motor transport and industrial emissions from enterprises. As you move away from the sources of emissions, the amount of heavy metals in conifers gradually decreases and reaches a minimum in the area of the Minino village for all components.

It should be noted that the proposed method of assessing the territory by bio-indication using Scots pine and Siberian spruce is very easy and does not require expensive equipment, it can be carried out on field trips in the absence of complex devices.

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血浆蛋白在实验压力下的功能
FUNCTIONING OF BLOOD PLASMA PROTEINS UNDER EXPERIMENTAL STRESS

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摘要。 在对亚毒性浓度的气态含硫污染物对未成熟雄性大鼠的影响进行实验研究的过程中，揭示了血浆中总蛋白质，白蛋白和球蛋白含量的动态。 时序生物学方法和生化方法的研究使全面研究正常条件下和长期暴露于含硫天然气中血浆蛋白昼夜节律的特征成为可能。 醉酒会导致总蛋白质含量近每小时的节奏波动发生最明显的变化，从而在年轻的成年期中使球蛋白的动力学曲线变得平滑。

关键词：Ultradian节律，大鼠，慢性中毒，蛋白质合成，应激。

Summary. *In the course of experimental studies on the effect of subtoxic concentrations of gaseous sulfur-containing pollutants on immature male rats, the dynamics of the content of total protein, albumin and globulins in blood plasma was revealed. The chronobiological approach and the biochemical method of research have made it possible to comprehensively study the features of the circadian rhythms of blood plasma proteins in normal conditions and under chronic exposure to sulfur-containing natural gas. Intoxication causes the most pronounced changes in the near-hourly rhythmic fluctuations in the total protein content, causes a smoothing of the kinetic curve of globulins in the young period of ontogenesis.*

Keywords: *Ultradian rhythms, rats, chronic intoxication, of protein synthesis, stress.*

It has now been established that ultradian rhythms (rhythms lasting less than a day) can serve as a reliable marker of morphological maturity and tissue functional activity [2, 3]. Observing the features of such fluctuations, it is possible to reveal a toxic effect, since they are associated with the specificity of cellular metabolism and reflect its instability.

Hydrogen sulfide-containing natural gas, having the ability to penetrate the histohematological barriers and acting in the volume of circulating blood, disrupts

metabolic processes between the microvasculature and cells [4, 5]. In mitochondria, hydrogen sulfide inhibits electron transport by forming a strong bond with iron in cytochrome oxidase molecules and promotes the development of acute tissue hypoxia [1, 6, 7].

The purpose and objectives of the work. To study the features of ultradianic rhythms of the synthesis of blood plasma proteins in rats - male young animals in normal conditions, with chronic exposure to sulfur-containing natural gas, as well as with the introduction of a complex of antioxidants. Determine the periods of increased sensitivity of blood plasma proteins under conditions of intoxication and the introduction of antioxidants.

Materials and research methods. 90 male outbred white rats served as the object of the study and were kept in a vivarium with free access to food and water. During the study, the animals were divided into three groups: control and two experimental. Control rats were kept for 4 hours in a hermetically sealed priming chamber, like the experimental ones, but without the presence of sulfur-containing gas. The first group of experimental animals was exposed to natural gas, at a concentration of 90 ± 4 mg/m^3 in terms of hydrogen sulfide for 6 weeks, 4 hours a day (Monday - Friday). The experimental animals of the second subgroup were injected intramuscularly with thymalin every other day during 6 weeks of the experiment at the rate of 0.01mg per 100g of body weight. Animals from the second subgroup were injected per os with a 10% oily solution of alpha-tocopherol acetate at a dose of 0.5mg per 100g of body weight of each animal for 14 days before the experiment and during the entire period of the experiment. To conduct chronobiological studies, control and experimental animals were anesthetized with sodium etaminal at a dose of 5mg per 100g of body weight (intraperitoneally), decapitation was performed, and blood was drawn every 20 minutes for 3 hours after the termination of the experiment. The biuret method was used to determine the total protein content in the blood plasma, and the amount of albumin was recorded by a unified method on a spectrophotometer at the corresponding wavelength of 630–690 nm. The data obtained were processed statistically using Microsoft Excel and Cosinor-Analysis software.

Research results and conclusions. Fluctuations in the content of total protein, albumin and globulins that we found are characterized as ultradian with periods of about 20 - 30 minutes. Analysis of the kinetic curve showed that the content of total protein in blood plasma in immature intact animals averaged 66.29 g/l and the amplitude of fluctuations was about 8% of the average.

The kinetic curve shows 2 significant peaks of total protein synthesis at 80 and 160 minutes. The average amount of globulins was 36.64 g/l with an amplitude of 21% of the average. Fluctuations in the level of albumin are in antiphase in comparison with the rhythmic fluctuations of the group of globulins. Under the toxic

effect of natural hydrogen sulfide gas, there is a significant decrease in the total protein content by 10%. During the observation period, there were 2 significant peaks of its synthetic activity at the 80th and 160th minutes by 17.3% and 12%, respectively. The amplitude of the oscillatory processes of the total protein was 8.5% of the average. The nature of the kinetic curve of globulins and albumin, smoother compared to the control values. The average content of globulins and albumin is 19.26 g/l, the amplitude of fluctuations is 5.4% and 13% of the average. Against the background of the complex introduction of antioxidants in chronic intoxication in young animals, there is a modification of the hourly oscillations.

More pronounced changes were revealed in the circadian rhythm of the level of total protein and globulins. The introduction of a complex of antioxidants (alpha-tocopherol and thymalin) contributes to a significant correction of the observed changes, increasing the amplitude of the oscillatory process of the total protein content, increasing the level of synthesis of all the parameters under consideration and also leads to the restoration of the circadian rhythm of globulins with a period of fluctuations of 60 minutes. In this group of proteins, 3 significant peaks of metabolic activity were revealed at the 20th, 80th, and 140th minutes. The average content of globulins was 41.2 g/l, which is 12.5% higher than in intact animals. The amplitude of fluctuations of this group of proteins was about 8.5% of the average. Analysis of the kinetic curve of the albumin content in the blood plasma of young animals under the same experimental conditions revealed three peaks of synthetic activity. The oscillation periods were 40 and 60 minutes with an amplitude of about 15% of the average.

This indicates the advisability of introducing antioxidants to a group of young animals against the background of chronic intoxication.

The results of the study indicate that the change in the oscillatory process that occurs under various physiological conditions and toxic effects has an adaptive character, providing optimal functioning of tissues and organs. Modification of circadian rhythmic processes mainly concerns the amplitude of oscillations, practically does not change the period of the ultradian rhythm, and is reversible.

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自由基及其在动物生存能力和繁殖中的作用
FREE RADICALS AND THEIR ROLE IN THE VIABILITY AND REPRODUCTION OF ANIMALS

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抽象。 基于我们自己的研究，以及对有关线粒体功能，动物的生存能力，繁殖力和生产力的依赖性，传染性疾病和非传染性疾病所决定的体细胞的生物物理潜力和代谢活性的现代知识的回顾 –感染的原因，在人体细胞的代谢活性和组织的自由基氧化水平进行了评估。 提出了一种假设，一方面通过下丘脑将线粒体能量重新分配到生长能量（生产力），另一方面通过生殖能量，这取决于代谢活动的水平和环境条件。
关键词：活力自由基氧化线粒体繁殖COVID-19

Abstract. *Based on our own research, as well as a review of modern knowledge about the biophysical potential and metabolic activity of body cells, determined by the function of mitochondria, the dependence of the viability, fertility and productivity of animals, diseases caused by infectious and non-infectious causes, on the levels of metabolic activity of body cells and free radical oxidation of tissue was assessed. A hypothesis has been proposed for the redistribution of mitochondrial energy through the hypothalamus to growth energy (productivity) on the one hand, and reproduction energy on the other, depending on the level of metabolic activity and environmental conditions on the other.*

Keywords: *vitality, free radical oxidation, mitochondria, reproduction, COVID-19*

The viability and fertility of living organisms, the productivity of farm animals are largely determined by the function of mitochondria, which produce biochemi-

cal energy, called ATP, by breaking down food with oxygen. At the same time, about 5% of oxygen, as a result of various reactions, turns into reactive oxygen species (ROS) - free radicals that destroy nearby cells and tissues, trying to take away the missing electron from them. Free radicals cause lipid peroxidation, damage DNA and alter biochemical compounds, corroding cell membranes and destroying cells (1). They especially oxidize the lipid membranes of cells, blood vessels of various tissues. At the same time, free radicals are the most important regulators of almost all life processes and the body needs them to produce energy and various substances that it needs.

The aim of this work is to assess the role of mitochondria and free radicals in the viability and reproduction of farm animals based on the materials of their own research and experimental data of other scientists.

In recent years, an interesting phenomenon has been observed in animal husbandry in many countries - in the process of intensification of animal husbandry, especially with industrial technologies of keeping, there is a decrease in life expectancy and economic use, especially of highly productive animals. These animals, especially broodstock, are in favorable conditions for feeding and keeping in accordance with all the rules of animal husbandry, except for movement and interaction with factors of the natural environment. They have a very high metabolic activity, as a result of which they show the highest productivity. An increase in the productivity of animals is accompanied by a decrease in their reproductive function. In many farms of the Russian Federation, the duration of productive use of dairy cows is reduced to 2-3 lactations, instead of 6-10 or more in ordinary peasant ones, calving of beef cows - up to 2.7, sows - up to 3-4 farrows. Many researchers explain this state of reduced viability and fertility of animals by metabolic or productive stress (2,3). In their opinion, it is caused by the activation of the lactation dominant as a result of selection for high milk productivity. In this case, there is an increased production of free radicals, accompanied by a number of disorders in the functioning of biological membranes, the functioning of cells and the redox balance.

We believe that the reduced reproductive ability, reduced life expectancy and economic use of highly productive animals caused by metabolic disorders are more consistent with the concept of metabolic syndrome (MS) (4). If in humans the prevalence of MS is associated with a high degree of sedentary lifestyle, then in animals with industrial technologies - with year-round maintenance without walking. In both cases, a lower activity of antioxidant enzymes in the blood plasma and higher levels of markers of oxidative damage, mainly lipid peroxidation, are observed. As follows from some works, this is due to the high activity of mitochondria and, accordingly, increased production of free radicals (5,6). The imbalance between the high production of free radicals, determined by the high produc-

tion of malondialdehyde (MDA) and the level of antioxidant defense of the body, causes a decrease in life expectancy due to various diseases, and most importantly, reproductive dysfunctions. This is reflected in an increase in the duration of the service period, a decrease in the effectiveness of artificial insemination, a decrease in the yield of young animals, and a decrease in the duration of productive use of animals (**7**). In cows and sows, limb weakness is observed, accompanied by chronic lameness.

Oxidative damage and dysfunction of the antioxidant system are common signs of many diseases of the central nervous system, including chronic pain and lameness in farm animals, which are widespread on large farms in Russia and other countries. Daniel Herzberg et al. (**8**) observed an increase in ROS, MDA and carbonyl groups in the spinal cord of dairy cows with chronic inflammatory claudication. Vitamin D is one of the powerful modulators of mitochondrial function and oxidative stress.In our experiments, UV irradiation of sows and piglets promoted an increase in the antioxidant activity of cell membrane lipids by 36-51% in pregnant sows, by 14-29% in lactating sows and a decrease in concentration total lipids by 3.8 - 15.1% depending on its dose. At the same time, the fertility and adaptive properties of pigs improved. So, under the influence of UV irradiation, the fertility of sows increased by 0.7 - 1.0 piglets, the yield of piglets for weaning - by 0.5-1.8 heads, the live weight of a piglet at weaning by 0.2-0.3 kg. It should be noted that the culling among the irradiated sows was 7-27% lower, and their fertilization after weaning was 10-15% higher than in the control (without irradiation) (**9**).

An increase in the antioxidant activity and lipid peroxidation of erythrocytes in piglets under the influence of various anti-stress substances (vitamins C and E, eleutherococcus extract, UV irradiation, etc.) was observed in our experiments. Antioxidant activity (AOA) increased under the influence of all the factors studied, especially when the extract of Eleutherococcus was added to mixed feed in combination with chlorpromazine and UV irradiation (P <0.01). However, the addition of eleutherococcus extract and chlorpromazine increased lipid peroxidation (LPO) (P <0.01), despite the increase in which, the predominance of the accumulation of antioxidant reserves over free radical reactions was observed, as evidenced by an increase in the AOA/LPO index. The use of UV irradiation contributed to a decrease in LPO values (P< 0,01) (**10**).

We have studied the dependence of pig fertility on the oxidative status of the blood of sows, blood and semen of boars, in particular, on the level of thiol compounds (SH-group), catalase (CAT) and MDA (**11**). A clear increase in the number of live-born piglets per farrow and the total weight of offspring was shown in those pairings when sows with a high level of SH-blood groups were inseminated with semen of boars with a high level of CAT blood. Sows with a low level of

SH-groups in the blood, fertilized with boar sperm with a low level of CAT in the blood, showed the lowest frequency (8.1 piglets). The highest fertility was obtained from sows with a high level of SH-groups, fertilized with sperm from boars with a high blood level of CAT (10.9 piglets), with a high degree of significance of the difference (P <0.01). The fact is that the main method of obtaining energy in the process of maturation of mammalian oocytes is oxidative metabolism (**12,13**). In this case, free radicals play a key role. Especially a lot of free radicals are formed in sperm cells, which are characterized by an extremely high metabolic rate. Spermatozoa are good producers of ROS, while at the same time they are particularly susceptible to oxidative damage that affects their structure and function. Since energy production and reactive oxygen species are closely related, and oocytes are the richest in mitochondria (**12**), oxidative damage leads to impairment of their function, which contributes to the formation of oxygen radicals and a decrease in ATP concentration. The leading role in the molecular mechanisms of antioxidant protection and bringing the concentration of free radicals to the physiologically necessary level belongs to thiol compounds, which have sulfhydryl groups (SH-groups), characterized by high reactivity (**14**). Sperm mitochondria, although they decompose within the zygote, their functionality is critical for fertilization (**15**). Antioxidant activity (AOA) retains its high status, achieved as a result of increased metabolism, the biophysical energy of the new organism is at a high level, which gives the best opportunities for its further development (**16**).

We associate the violation of the reproductive function of highly productive animals with a special category of life called by E. S. Bauer "The main process" (**17**). It lies in the fact that in the process of development and aging of the organism under the influence of environmental factors, the free energy possessed by a living substance decreases, and in its generative cells it increases sharply. The energy of the egg is the source of the structural energy of the body throughout its life (**5,17**). In a number of experiments by various scientists (**18**), it was shown that the germ cell is enriched with energy due to the energy of the whole organism and depending on the conditions of its vital activity. When the body is exposed to certain stresses (within the normal reaction range), the more energy is stored in the eggs, which have a large supply of mitochondria. Mitochondria produce an important peptide - humanin, which is encoded in the mitochondrial genome, circulates throughout the body and is directly connected to the hypothalamus, which is the center of energy metabolism control that affects sexual and reproductive behavior (**19**).

It has been shown that mitochondria signal their metabolic state to the nucleus and other cells in response to stress (**20,21**). They are believed to play a critical role in innate immune signaling against viruses and in the production of protective interferons (**22**). Perceiving the state of the body in terms of energy consump-

tion and fuel sufficiency, mitochondria act in a sense as a single organ, sending signals that regulate metabolism and affect life expectancy. Moreover, the hypothalamus can be the regulator of the process of directing energy to the growth and development of the body or to the energy enrichment of eggs, sperm, that is, to reproduction, depending on the interaction of the body with the environment, in particular, on the conditions of detention, nutrition and, in general, on the state of health organism. In conditions of insufficient life support, the body strives for the fastest reproduction of its own kind, for eternal life expectancy through a change of generations. Stressful factors can be a stimulating factor for this. Fertility, live weight of animals at birth and their viability, as well as immune properties, are obviously largely determined by the development of an egg (sperm), that is, they depend on the level of biophysiological energy accumulated by it, obtained from the original parental forms.

Indicators of antioxidant activity, the level of free radicals (ROS) both in absolute values and in the form of an index of oxidative stress can serve as the main criteria for metabolic status, human vitality, productivity and fertility of animals (**23**). It is known that free radicals are very aggressive, ready to infect any cell, especially lipid layers containing polyunsaturated fatty acids, which can be most strongly oxidized. However, if they are so aggressive, why can't they infect microbial or viral cells? After all, there are millions of them. If we assume that free radicals infect these cells, then the degree of destruction of infectious agents, prevention and treatment of diseases depends on the work of mitochondria, on the level of free radicals produced by them. For some reason, this factor in modern medicine, for example, in the fight against Covid-19, is not taken into account at all. Meanwhile, the conditions and intensity of work of the mitochondria themselves are well known, so it is possible to influence the production of free radicals by them. So, it is known that with a lack of nutrients in the diet, very few free radicals come out of the electronic transport chain, and with excessive consumption of calories, on the contrary, there are too many of them. In the second case, obesity and accelerated aging are observed in humans, in highly productive cows - various non-communicable diseases, poor reproduction and premature culling. There are reports that the Covid-19 virus affects most and most people from poor families (black residents of the United States), as well as the elderly and old. Their body produces few free radicals that cannot be attacked by infectious agents. People and animals with high metabolic activity have a large reserve of free radicals, which, it is believed, are capable of infecting microbial and viral cells. It is known that the Covid-19 virus consists of several layers of easily oxidized fatty acids, including a two-layer lipid membrane, so it can be destroyed most easily by free radicals. Therefore, if this thesis is taken as a basis, then it becomes clear that in order to combat infectious agents, it is necessary to use the maximum level of nutrition

during an epidemic, with a minimum of antioxidants that neutralize free radicals. Then it will be possible to use the work of the mitochondria of cells of a living organism for the prevention and treatment of various infectious diseases (coronavirus COVID-19, African swine fever, etc.) by regulating the level of free radicals and neutralizing harmful factors (viruses, bacteria) by them.

Our **hypothesis** is as follows.

In the human and animal body, biophysical energy, through the interconnection of mitochondria and hypothalamus, is redistributed into growth energy (productivity), on the one hand, and reproduction energy, on the other, depending on the level of metabolic activity and environmental conditions.

- Under favorable conditions for the nutrition and life of people, feeding and keeping animals, high metabolic and mitochondrial activity of the body, the absence of stress, an increase in the production of reactive oxygen species has a negative effect on the body. The fertility and duration of the economic use of farm animals decreases. At the same time, the increased level of free radicals can be useful as a neutralizer of various viruses such as COVID-19 and bacteria, especially those with readily oxidizable lipid membranes. Therefore, during an epidemic of viral diseases, it is necessary to limit the use of antioxidants.

- Under unfavorable living conditions, under the influence of moderate stress, decreased activity of mitochondria, reduced metabolism, the body is more exposed to infections, due to insufficient levels of free radicals that can neutralize infectious agents. The body's energy is switched to reproductive function, which is carried out through the hypothalamus with the help of a special protein - humanin, produced by the mitochondrial genome

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"一带一路"项目背景下的人口分布新趋势（以" TRANS–西伯利亚"地区为例）

NEW TRENDS OF THE DISTRIBUTION OF POPULATION IN THE CONTEXT OF THE PROJECT "ONE BELT – ONE ROAD" (ON THE EXAMPLE OF THE "TRANS-SIBERIAN" REGIONS)

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注解。　 本文讨论了在乌兰乌德–新西伯利亚地区与TRANS–西伯利亚领土相邻的城乡人口的现代分布，人口，社会经济状况和特征。　 确定了创建高铁和欧亚经济走廊基础设施的机会和障碍。

关键词："一带一路"项目，人口潜力，新丝绸之路，农村人口，经济合作，西伯利亚，城市安置，过境走廊。

Annotation. *The paper discusses modern distribution of rural and urban population, demographic, socio-economic conditions and features adjacent to the TRANS-Siberian territory in the area of Ulan-Ude – Novosibirsk. Identified opportunities and barriers for creation of infrastructure of high-speed rail transport and Eurasian economic corridor.*

Keywords: *the project "One belt – One road", demographic potential, New silk road, rural population, economic cooperation, Transsib, urban resettlement, transit corridor.*

The fundamental importance of transport in the spatial development of the country, the formation and functioning of differentiated settlement systems and territorial structure of the economy is difficult to overestimate. Historically, the geographical location of the settlements one way or another been associated with the presence of traffic arteries, and relationships: the position of river crossing, trade and river pathes, a convenient dock – all this can cause settlement.

The modern global transport system is the basis of the international division of labour, exerting a direct influence on the distribution of productive forces and economic efficiency, the deepening and widening of integration processes on a global scale, contributing to the formation and the development of new spatial forms of settlement. As a result, increases the interdependence of processes, conditions

and mechanisms that determine the development of the city and district, and it becomes obvious the need for their comparative analysis on different taxonomic levels – from local to global.

The Trans-Siberian Railway is one of the most powerful land transport arteries of the world. For almost a century it was the only transit transcontinental railway. Currently other alternative ways through the Eurasian continent are actively created or developed. So, among the rail routes the main competitor for the Transsib could be the North corridor of the New Silk Road in the near future, which, starting on the coast of the Yellow Sea, crosses the territory of China and Kazakhstan, and then Russia. The Chinese part also proposed to consider the option of building a high-speed railroad from Beijing to Moscow via Mongolia with access to the Trans-Siberian Railway in Ulan-Ude.

In this paper we attempt to solve such urgent problems as geographical study of socio-demographic and population conditions and features adjacent to the Trans-Siberian territory, bearing in mind the prospect of construction the high speed railway and the Eurasian economic corridor as a whole. As a model we selected a section of the Trans-Siberian Railway, 2,300 kilometers long, between the cities of Ulan-Ude and Novosibirsk, where the highway crosses from east to west five entities of the Russian Federation: the Republic of Buryatia, Irkutsk, Krasnoyarsk, Novosibirsk and Kemerovo oblasts.

Distribution of rural population

Distribution of rural population is a form of spatial organization of livelihoods of people in the non-urban areas as a set of rural populated areas of various types, designed for permanent or temporary residence [1, p. 391]. Over the last quarter century, the geographical pattern of the distribution of rural population in Siberia has undergone major changes: after the weakening of economic growth impact was the gradual "compression" of rural "oecumene" and the transformation of its structure from the areal into a linearly-node, thereby reinforcing the trend of polarization and concentration of rural population within the narrow band along the Trans-Siberian Railway (here and after "transsiberian" areas).

The band area within five subjects of the Siberian Federal District (Republic of Buryatia, Irkutsk, Kemerovo, and Novosibirsk oblasts and Krasnoyarsk krai) due to the most favorable climatic conditions, the levels of socio-economic, medical and demographic development and infrastructure security is the most developed and densely populated area of distribution of rural population (Tab. 1).

In less populated areas, mainly to the north of the Trans-Siberian Railway, the concentration of rural settlements becomes dispersed or focal character. The relatively densely populated areas are often separated from each other. They are often associated only with arterial roads or seasonal lines of communication: navigable waterway and winter roads.

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The most sparsely populated area is in the Republic of Buryatia, the average population density is 2.8 pers./km². For the settlement system of the republic as a agro-industrial region characteristic is a sharp predominance of rural settlements over the urban and a relatively high proportion of the rural population, more than 40% of the total population residing in the Republic; the highest population density is in its central part in the Selenga river basin, just along the Trans-Siberian Railway. In the Ivolginskii (more than 7.5 pers./km²), Zaigraevskii (7.7 pers./km²), Tarbagataiskii (7.4 pers./km²) and in the Kabanskii districts (4.8 pers./km²). Geographical differences manifest themselves in settlement specialization, along the railway the settlements, operating industrial and transport functions dominate, so the settlements located in the southern part of Buryatia are mainly agricultural.

Table 1

The structure of distribution of rural population on the subjects of the Siberian Federal District (January 1, 2018)

Region	Total rural population, people	Rural population of the Trans-Siberian areas, pers.	The area of the territory, thou km², totally/ within the Transsib zone	Number of rural settlements: totally/within the Transsib zone
Republic of Buryatia	402 106	157 463	353.1/41.3	250/59
Irkutsk oblast	508 461	289 424	774.8/157.4	363/194
Krasnoyarsk krai	665 073	158 461	2366.8/52.8	488/111
Kemerovo oblast	389 005	127 965	95.7/21.7	154/63
Novosibirsk oblast	590 004	283 638	177.8/8.8	429/166

In Irkutsk oblast the baseband of rural settlement along the railway stretches from the western boundary of the area to Lake Baikal. The rural population accounts for 21% of the total number of residents, more than 60% of them are concentrated in the settlements of the railway-side area, the size of the settlements is 200-500 persons on average. In this large area of agricultural development there is a plurality of agrarian and agricultural settlements, most of the major administrative and economic center with a predominance of forestry enterprises. According to population density, there are three main groups of areas: 1. forest steppe agricultural areas of the Ust-Ordynskii Buryatskii Autonomous District; 2. suburban areas of the south-eastern part of the region with relatively favorable conditions for agriculture and private farming (Irkutsk, Angarsk, Shelekhov, Cheremkhovo, Usolye, Slyudyansky, Zalarinsky, Zima); 3. northwestern "transsiberian" areas: Tulun, Nizhneudinsk, Taishet.

In Krasnoyarsk krai the Trans-Siberian Railway passes in a latitudinal direction through its southern part, which is the most densely populated habitat of rural settlements. There is more than 80% of population of the region. Regional settlement system comprises 488 rural settlements, which are home to 23.5% of the population. For the Transsib zone the suburban form of rural settlement is characteristic: the number of people who buy houses and land plots within settlements has increased dramatically in the past few years, the same goes for the number of suburban dachas, united in partnerships. The general trend for this area is the less outflow of rural residents compared with residents of urban settlements; nevertheless, in recent years this process has contributed to an increase in the number of small rural settlements with a population of up to 100 people.

For Kemerovo oblast the Trans-Siberian vector of population distribution is not determinative in the statistics of the most densely populated and cultivated areas (for the reason specified in Section 4.2.). On the contrary, unlike other subjects the SFO, there is a reduction in the rural population in the most affected districts Izhmorskii (3.1% in 2015 population decline compared to 2014), Tisulskii (by 2.3%) and Yaiskii (by 2.1%). The region is one of the most highly urbanized, industrial specialization of its economy has led to a significant excess of the proportion of the urban population over the rural (85.7% vs. 14.3%) [2]. However, in recent years, the rural population of the region decreased more slowly than urban, more than that, we watched its slight increase in a number of settlements. This trend is largely explained by the administrative-territorial transformations: changes in the status of the workers' settlements and their transfer into the category of villages.

Novosibirsk oblast, being located in the southern part of Western Siberia, on the Trans-Siberian Railway axis, is also among the most populated and cultivated areas of the Asian part of Russia. The distribution structure is extremely heterogeneous here, as in most of the eastern regions of the country: the increasing concentration of population in settlement with low population density (almost always larger and more viable) with significant increase of the value of a certain type of settlements in structural terms, and in the territorial. The most population of Trans-Siberian districts of the region is concentrated in cities and towns; the rural population is more than 4 times lower than the urban, the northern and remote areas are less inhabited. The average area density of the rural population is 6 pers./km², the highest density (up to 40 pers./km²) is observed in Novosibirsk oblast as the main zone of attraction for the internal migration flows, as well as in the group of regions with favorable transportation and geographical status and more favorable climatic conditions (Karasukskii, Chanovskii, Suzunskii, Ordynskii, Krasnoozerskii); less populated are the Northern and Kyshtovskii district (0.7-0.9 pers./km²on average) [3].

Currently, the system of distribution of rural population of the majority of Siberian regions is at the bifurcation point, in a state of various development scenarios. The trend of contraction of rural settlement around major organizational and economic centers and along the main axes of distribution – the large river systems and transport arteries will continue in the near future under the influence of both internal and external factors.

Urban population

Urban population distribution is represented by two types of settlements - cities and towns. In addition, for the implementation of local self-government there is still a municipal division into urban settlements which are a part of municipal districts and urban districts – the formation of the same order with the municipal districts.

More than half of the Siberian towns gained the urban status in the postwar period, but in 1992 the formation of new cities stopped.

The urban population is completely dominated (86.4%) in the Trans-Siberian area. while it is 72.7% in the Siberian Federal District (Tab. 2).

In the Trans-Siberian areas where regions are headed by the million-strong cities Novosibirsk and Krasnoyarsk, the proportion of urban population exceeds 90%. Buryatia is characterized by a low level of urbanization, and even 4 municipal districts, located in the Trans-Siberian Railway area are headed by rural settlements. The relatively low share of urban population in the Trans-Siberian part of the most highly urbanized Kemerovo oblast is caused by the fact that the largest cities of the oblast (Kemerovo and Novokuznetsk) are located away from the Trans-Siberian Railway, and the centers of other regions are located directly on the railway.

Table 2
Urban settlements in the Trans-Siberian area in 2018
(January 1, 2018)

Region	Number of urban settlements		Urban population. thou. people	Share of urban population. %	Area for one urban settlement. thou km^2
	Cities	Town ships			
Republic of Buryatia	2	4	468.2	74.8	6.9
Irkutsk oblast	15	21	1376.4	81.9	4.4
Krasnoyarsk krai	11	9	1520.6	90.6	2.6
Kemerovo oblast	4	5	262.0	75.2	2.4
Novosibirsk oblast	4	4	1764.9	92.7	1.1
In total	36	43	5392.1	86.4	3.6

The largest number of cities (15) and townships (21) is located in Irkutsk oblast along the more than 800-kilometer long section of the railway, where the territory of the near band areas is up to 157.4 thou km^2. However, the average distance between urban settlements in the Irkutsk area is greater than the average for the Trans-Siberian Railway area. The highest density of urban settlements is registered in the eastern part of Novosibirsk oblast, where every urban settlement accounts 1.1 thou km^2. The rarest network of urban settlements is in the Republic of Buryatia. In other words, from east to west the density network of urban settlements consistently increases.

Regimentation of 36 cities according to the population size on 01.01.2015, calculated according to the source is as follows: more than 1 million - 2 cities; 100 thou - 1 million people – 5 cities; 50-100 thou people - 6; 20-50 thousand -12; less than 20 thousand - 11 towns. Urban settlements (43) are fairly evenly distributed across the four groups of population size: up to 3 thousand people - 12; 3-5 thou people - 9; 5-10 thou people - 15; more than 10 thou people - 10 settlements. The average population size of the settlement is 7.2 thou people, while in the largest settlements Krasnoobsk (Novosibirsk oblast) and Berezovka (Krasnoyarsk krai) the population number is more than twenty thousand people. More than one-quarter of all urban settlements, namely twelve serve as centers of municipal districts.

Number of urban settlements is reducing due to their transformation into rural settlements. This process had two peaks, corresponding to the reforms of the early 1990s and municipal reform of 2004. However, for Siberia villages are more significant in comparison with the western regions of Russia because of the greater dispersal of natural-resource potential of the territory. Thus, in the Transsib zone about 5% of population lives in villages, as well as in European Russia, while outside the Transsib zone 8% of population lives in villages.

According to population size among urban districts the regional centers are distinguished in the first place. Statistical data on urban districts give an idea of the high degree of differentiation: in population number (from 13.1 thou people in Svirsk and 14.8 in the urban settlement Koltsovo to 1567.1 thou people in Novosibirsk), and in population density (from 58 to 3122 inhabitants/km^2 in Novosibirsk).

The cities of the Trans-Siberian urbanized space - the centers of federal entities (Novosibirsk, Krasnoyarsk, Irkutsk, and Ulan-Ude) exert decisive influence on the development of Siberian regions. These cities have 58.8% of the population of the Transsib zone. The socio-economic potential of the major cities of southern Siberia is influenced by powerful transport and geographic development factors. There is an increasing polarization of the "center-periphery" in the economic and social aspects. In fact, the entire periphery of a migration donor for Siberian "capital cities" .If during the Soviet period the main changes in the urban system were unidirectional in the form of urban growth then the changes in the post-Soviet period have been immeasurably complicated.

There is a strengthening of the processes of socio-economic development in the territories of higher-urbanized areas, formed by the largest cities. In the Transsib zone (from Ulan-Ude to Novosibirsk) there are 7 large (population size of over 100 thou people) cities, which include 4 regional centers and 3 industrial cities (Angarsk, Achinsk, and Berdsk). There is a concentration of population and most highly paid activities in the largest cities of Siberia, as a rule, in regional centers.

The cities with a population of less than 50 thousand inhabitants are mostly large in number – 23 of 36 Siberian cities along the Trans-Siberian Railway. These cities fulfill two groups of functions: the local organizing centers of regional scale and specialized production centers. If the first group has internal development opportunities, meeting the requirements of its district, then the second group of functions is entirely dependent on external factors, on the demand for products and services outside of the city in the nearby area. There is a problem of maintenance of the local centers of large areas with a weekly developed infrastructure, and these are almost all territories, not confined to the Trans-Siberian Railway. Based on the fact that the functions of the regional centers are fulfilled by 19 towns, 12 urban settlements and 8 villages, we can conclude about the lack of cities, even in the most developed part of Siberia.

There is a strengthening of economic and social problems of small multi-functional urban settlements in Siberia, where a significant number of Soviet specialized productions fell out from territorial division of labor, have not found their level in the modern competitive environment. Noncompetitiveness of the major products of the local economic mainstay makes a town unsustainable.

According to the Decree of the RF Government Decree No. 1398-r of 29.10.2014, the list of single-industry municipalities was divided into three subgroups (Order 2014). The first sub-group with the most difficult socio-economic situation, including in relation to the problems of functioning of the enterprises with the city-forming role for 2016 include the towns: Baikalsk, Tulun, Usolye-Sibirskoe (Irkutsk oblast); Anzhero-Sudzhensk (Kemerovo oblast). The subgroup of single-industry municipalities with the risks of worsening socio-economic situation includes: Cheremkhovo, Sayansk (Irkutsk oblast); Mariinsk, urban settlement Yashkino, Taiga, Yurga (Kemerovo oblast); Borodino, Zelenogorsk (Krasnoyarsk krai); urban settlement Kamensk (Buryatia Republic) The third subgroup of single-industry municipalities with stable socio-economic situation does not include transsiberian towns.

Promising are the following types of small towns: community centers, heading development of areas with service functions and production, oriented on the local market; placements of individual industries in large urban agglomerations; centers of recreation and tourism, especially in the tourism and recreational areas.

In general, system of urban population distribution in the Transsib zone is highly advanced compared to other Siberian territories. There is a relatively high density of the network of urban settlements here; the main Siberian centers are located here, concentrating the population, modern manufacturing and innovative industries, transit transportation facilities and managing bodies of Siberian regions.

Conclusion

The study has significantly clarified and systematized existing geographical knowledge about socio-demographic and population distributional conditions and characteristics of the Transsib zone. It was found that, in contrast to the depopulating peripheral areas, population growth is observed within the Transsib zone, as well as the population density is higher than average several-fold, migration redistribution of the population is directed strictly in favor of the regional centers – Novosibirsk, Krasnoyarsk, Irkutsk and Ulan-Ude, actually being the agglomerations. Thus, the area adjacent to the Trans-Siberian Railway are in the Main population distribution zone of Russia and has the most favorable opportunities for implementation of new major transport projects in Siberia, including the construction of high-speed railway and to further overall economic growth. These features include the following: relatively comfortable climatic conditions and the most leveled terrain (with the exception of an area adjacent to Lake Baikal.); relatively high degree of development and population level; rather developed agriculture, which allows to ensure food security; advantageous transport and geographical position on the main latitudinal way of the country (the presence of parallel Moskow tract, the main oil pipeline, the line fiber-optic communications, etc.).

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用于生产新多功能产品的小粒油料种子的生物技术
BIOTECHNOLOGY IN THE STORAGE OF SMALL-GRAIN OILSEEDS FOR THE PRODUCTION OF NEW MULTIFUNCTIONAL PRODUCTS

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抽象。 首先，由于功能食品是天然成分，现代社会中的合理营养首先是人类健康的科学方法。 编制均衡饮食的复杂性归因于构成均衡饮食概念的各种因素。由于其成分中含有人体必需的所有维生素和微量元素，因此适合所有人群并经常使用，以维持和改善健康。 合理的营养可分为三个基本原则：1-食物进入人体并在生活过程中消耗的能量的平衡； 2-组成饮食以获取身体能量的主要物质的均衡组合； 3-各种菜肴，包括产品的最佳选择，使用的规律性，破碎性。
关键词：粮食，粮食储藏，粮食生物技术，收获后加工

Abstract. *Rational nutrition in modern society is, first of all, a scientific approach to human health, since functional foods are products of natural composition. The complexity of compiling a balanced diet is due to various factors that make up the concept of a balanced diet. It is intended for all groups of the population and regular use in order to maintain and improve health due to the presence in its composition of all vitamins and microelements necessary for the body. Rational nutrition is subdivided into three basic principles: 1 - the balance of energy entering the body with food and consumed in the process of life; 2 - a balanced combination of the main substances that make up the diet to obtain energy for the body; 3 - a variety of dishes, which includes the optimal selection of products, regularity of use, fragmentation.*

Keywords: *grain, grain storage, grain biotechnology, post-harvest processing*

As a rule, in practice, these principles are not fully observed due to the active

rhythm of life of the population of large cities. Also, a complicating factor in adherence to the basic principles of good nutrition is the social and psychological aspects of people, namely: their habits and taste preferences. And, as a consequence, a deficiency of micronutrients occurs in the human body and the risk of developing diseases associated with nutrition increases. Genes cannot be corrected through nutrition, however, prevention of various diseases is possible. Figure 1 shows the result of a deficiency of organic substances under the insufficient consumption of cereals and oilseeds [1], [2].
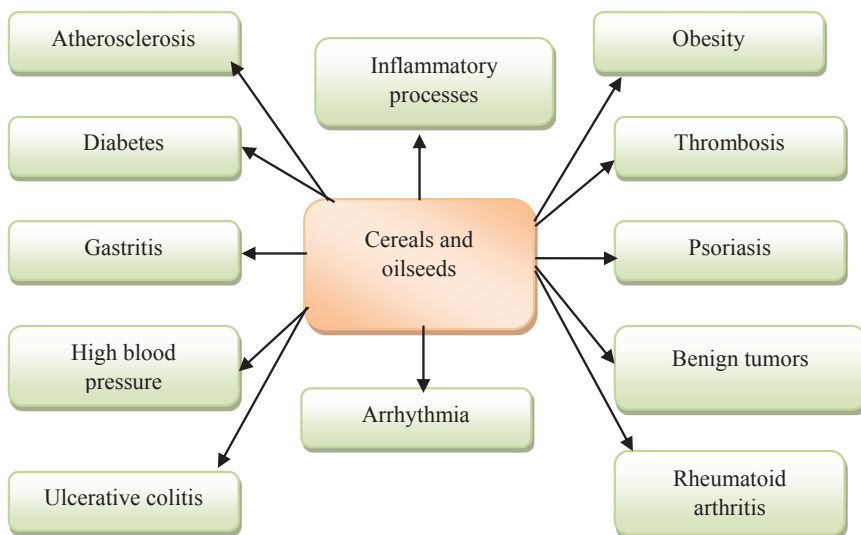
Figure 1 – The result of a deficiency of organic substances under insufficient consumption of cereals and oilseeds

The production of such products sets a new direction for the development of the food industry, the creation of improved technologies and recipes.

We will form the principles and factors for the formation of the quality of organic grain products.

Principles of shaping the quality of organic grain products:

1. Safety.

2. Ensuring the nutritional value of the product:

- organoleptic and physical and chemical indicators;

- the appearance of the package;

- information for the consumer about quality;

- direction of product use.

Factors shaping the quality of grain products:

1. The ability of industrial enterprises to promptly use the latest achievements of scientific and technological progress.

2. Study of the requirements of the domestic and international market for the needs of various categories.

3. Training of workers and managers, systematic advanced training, the use of incentives of a material and moral nature.

A key aspect in the creation of new multifunctional products for a wide variety of purposes is high-quality grain raw materials, as well as its harvesting, processing, storage and use of genetically inherent capabilities of the variety. Due to insufficient implementation of innovative technologies and modern technology, it is not possible to keep the harvested crop with minimal losses. The reasons that impede the development of quality systems at food enterprises have been identified (Figure 2).

Reasons hindering the development of quality systems in food enterprises

| Lack of economic freedom among enterprises, necessary for the further development of production | Inflation | Violation of the structure of interaction between enterprises, which causes significant difficulties with material and technical support and equipment |
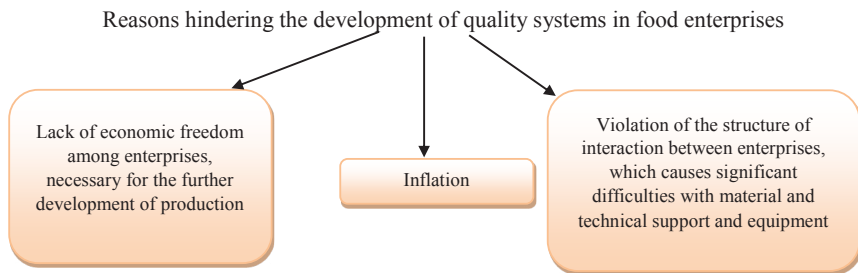
Figure 2 – Reasons hindering the development of quality systems in food enterprises

For 2020 in the Russian Federation in the structure of sown areas, the largest share is occupied by: wheat - 36.9%, barley - 10.7%, sunflower - 10.6%. In the production of small-grain oilseeds, traditional for the Russian Federation, there is a tendency to increase to 21.8 million tons due to the expansion of sown areas. In recent years, the production of both sunflower and other oilseeds has been actively developing in our country, namely: soybeans, rapeseed, flax, safflower, mustard and hemp. Sunflower, soybeans and rapeseed make up 90% of the total oilseed production in Russia [3].

Small-grain oilseeds are plants that contain an increased amount of fat and are the starting material for the production of vegetable oil, which plays a huge role in the food technical industries. According to the amount of oil content, seeds are divided into:

1. Low-oil seeds (15-35% oil in the kernel).

2. Medium-oil seeds (36–55% oil in the kernel).

3. High-oil seeds (56-75% or more oil in the kernel).

The processing of flax and mustard in the country is decreasing due to a decrease in yields due to the postponement of sowing and weather anomalies in spring. In 2018, the yield of flax was 432 thousand tons, but by 2019 it had dropped by 48%, and mustard yield decreased by 10%. According to Rosstat, the processing of rapeseed and hemp in the period from 2018 to 2020 increased significantly (Figure 3). In 2018, rapeseed amounted to 137 thousand tons and increased to 169 thousand tons. By 2020, the processing of hemp has increased compared to 2018 by 40% [4], [5].
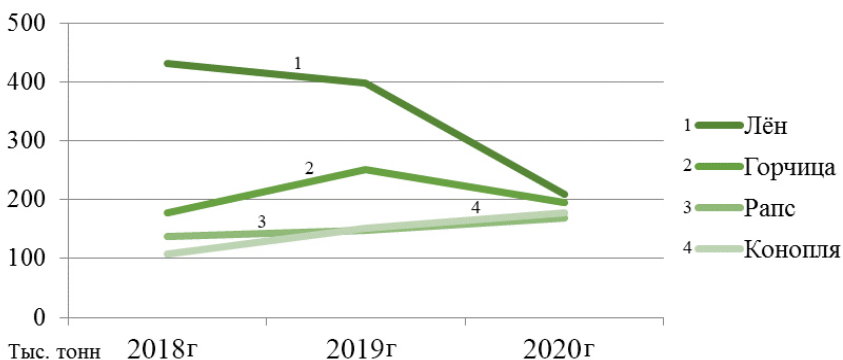
Figure 3 - Processing of small- grain oilseeds in Russia in 2018-2020

The valuable qualities of small-grain oilseed raw materials, as well as its technological advantages are determined by its chemical composition, therefore it is controlled during the development of new varieties, post-harvest processing and storage [6].

Table 1 - Chemical composition of oilseeds

Content per 100 g of product	Flax	Mustard	Rapeseed	Hemp
Water	6,96	5,27	8,1	4,96
Protein	18,29	26,08	30,8	31,56
Fats	42,16	36,24	43,6	48,75
Carbohydrates	1.58	28,09	7,2	8,67
Sugars	1,55	6,8	3,5	1,5
Alimentary fiber	27,3	12,2	5,8	4
Ash	3,72	4,33	4,5	6,06
Vitamin E, mg	0,31	5,1	7,4	0,8

Vitamin B1, mg	1,64	0,8	0,11	1,3
Vitamin B2, mg	0,16	0,3	0,25	0,3
Vitamin B6, mg	0,47	0,4	-	0,6
K, mg	813	738	979	1200
Ca, mg	255	266	454	70
Mg, mg	392	370	311	700
P, mg	642	828	840	1650
Fe, mg	5,73	9,2	6,3	8
Mn, mg	2,48	2.4	-	7,6
Cu, mg	0,12	0,6	-	1,6

In addition to lipids, the seeds of oil plants contain many protein substances, which, after the extraction of oil from the seeds, remain in the fat-free meal. The protein complex of seeds and products of their processing can be characterized by the ratio of proteins soluble in water. Of greatest importance is the thermal denaturation of proteins, with the help of which the defatted material is given the necessary structure and physical and mechanical properties, although denaturation of proteins is possible under large mechanical influences on seeds and their processing products, as well as under the action of organic solvents. Substances of carbohydrate nature are presented in seeds mainly in the form of cellulose and hemicelluloses, which form the cell walls of the seed tissues. The mechanical strength of seed tissues is primarily due to the presence of substances of this group [7], [8].

Oilseeds contain almost twice as much ash than non-oilseeds. Ash elements are predominantly included in the biological substances of the embryo and endosperm of seeds and processed products, they are concentrated in the meal, increasing its feed value.

Hemp seeds do not contain gluten, as a result, this product can be used by people with celiac disease, since oats, wheat, rye and barley are contraindicated for them [9].

A feature of oil plants is their ability to accumulate more fatty oils during ripening. During the period of seed ripening, fatty acids are synthesized, formed as a result of photosynthesis in green plants and in the root system from substances entering through the soil.

To determine the processing scheme and purification modes of small-grain oilseed raw materials during its accepting, it is necessary to determine the organoleptic and physicochemical characteristics of the raw material. Quality indicators are presented in table 2.

Table 2 - Indicators of the quality of oilseeds

Name	Indicator	Characteristic
Organoleptic		
Color, smell, taste	-	Inherent in healthy grain, without foreign tastes and odors
Physicochemical		
Humidity, %	No higher than 9	
Fat content,%	No more than 3.5	
Nature, g/l	No lower than 800	-
Pollution,%	Not allowed	
Contamination,%	Not allowed	

The main feature of the quality of oilseeds is the fat content. In different oilseeds, its content is different. It depends on the variety, the conditions in which the seed grew, the degree of seed maturity. For oil mills, the value of grain is determined by the fat content: the more it is, the more valuable the raw material.

Figure 4 shows the technological scheme for processing oilseeds.
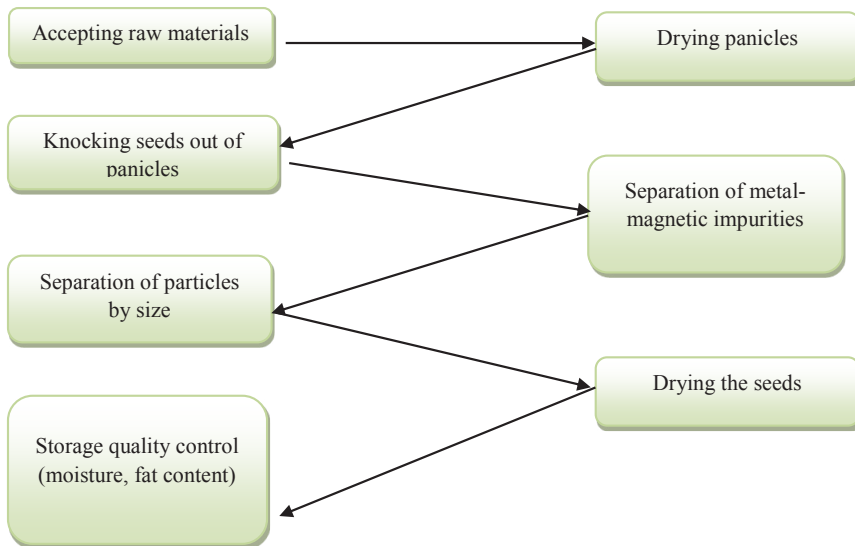
Figure 4 - Technological scheme for processing oilseeds

Drying of seeds is a necessary post-harvest manufacturing process, ensuring full preservation of its quality. It is recommended to carry out it in shaft grain dryers (VESTA 50, productivity 63 tons/hour; ATM417 - Sh, productivity 66 tons/hour; SSHV 7-18, productivity 67 tons/hour) with gentle modes: the air is heated to 80°C, so as not there was a reaction of melanoid formation. Table 3 shows the optimal modes for drying oilseeds.

Table 3 - Modes of oilseed drying

Moisture content of oilseeds,%	dry state according to GOST,%	Maximum permissible temperature for heating seeds °C	Drying agent temperature in the zone, °C	
			I	II
9-10		55	80	90
14		50	75	85
18	7	45	70	80
Above 18		40	65	75

Biotechnology is the industrial use of biological processes and systems. The efficiency of biotechnological processes is increased due to the selection of highly productive varieties. The biotechnological process is represented by the following stages: preparation of raw materials, purification, processing, isolation, modification and use of the obtained products.

To carry out this complex multistage process, various kinds of specialists are involved: genetics and molecular biologists, cytologists, biochemists, virologists, microbiologists and physiologists, process engineers and designers of biotechnological equipment.

Thus, the cultivation and high-quality processing and storage of oilseeds is a promising area of agriculture due to the demand for processed products: high oleic oil, meal and cake, which are used in the agro-industrial complex. These crops are able to compete with traditional grain raw materials, since in the form of flour and cereals they can be used as products of broad functional action for mass consumption by the population in the framework of healthy organic nutrition, the relevance of which is increasing every year.

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评估开放收集器对水体水化学状态的影响
ASSESSMENT OF THE IMPACT WATER FROM OPEN COLLECTORS ON THE HYDROCHEMICAL REGIME OF WATER BODIES

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抽象。 当前，紧迫的问题是位于集水器-排水网络影响区域的天然水体中成盐离子的浓度逐渐增加。 以俄罗斯南部的一个农业地区为例，研究了土渠中集水器，水体（排水和废水的接收器）以及主渠中水的化学组成，这表明了地球化学 均衡成盐离子的浓度。 根据V.V. 沙巴诺娃（Shabanova）在DWW的影响区显示水体中水质等级没有变化，这表明对无围网地质系统的水化学状况的破坏最小。
关键词：土床集水器天然水体水化学状态矿化

Abstract. *Currently, an urgent problem is a gradual increase in the concentration of salt-forming ions in natural water bodies located in the zone of influence of collector-drainage networks. On the example of one of the agricultural regions of southern Russia, the chemical composition of water in open collectors in an earthen channel, water bodies - receivers of drainage and waste waters, as well as a main canal, was studied, which showed the geochemical equalization of the concentrations of salt-forming ions. A comparative assessment of the quality of water in an open collector in an earthen channel and in a water body - a DWW receiver according to the method of V.V. Shabanova, who showed the absence of a change in the water quality class in a water body in the zone of influence of DWW, which indicates minimal damage to the hydrochemical regime of the seineless geosystem.*

Keywords: *open collector in an earthen bed, natural water body, hydrochemical regime, mineralization.*

The construction of reservoirs solved the problems of irrigation and watering of large irrigated areas of Russia, but at the same time, after half a century, many environmental problems arose associated with the operation of irrigation and drainage systems: soil salinization, which reduces crop yields; an increase

in the concentration of salt-forming ions and the salinity of river waters. At the beginning of the XXI century, with a noticeable warming of the climate, which led to a sharp decrease in the water content of rivers, the problem of a shortage of fresh natural water became aggravated. On the other hand, under the conditions of import substitution, the production of vegetable crops requiring large volumes of irrigation water increased.

A comprehensive solution to these problems is the use of drip irrigation, the competent use of agrotechnical methods: crop rotation, deep plowing of soils, cyclic use of rainfed and irrigated lands. Nevertheless, the problem of a gradual increase in the concentration of salt-forming ions in natural waters remains urgent [1-5].

In the conditions of irrigated agriculture, the chemical composition of irrigated water and the processes of its interaction with soils, the chemical composition of groundwater, are of decisive importance for the hydrochemical regime of the basin geosystem.

The use of drainage can prevent salinization and flooding of irrigated areas during the irrigation period. However, a secondary problem arises - the formation of huge volumes of polluted drainage wastewater (on average 20-25 million m^3/ha per year).

The ecological situation of the basin geosystem on agricultural landscapes largely depends on the type of drainage: open or closed.

The object of the study was an open collector-drainage network in an earthen bed (for example, one of the agricultural regions of southern Russia).

The aim of the research was to establish the degree of impact of an open collector-drainage network on the hydrochemical regime of natural water bodies - drainage-waste water receivers (DWW).

Open reservoirs in the earthen channel should be considered as a hydraulically connected natural-technical system in the basin geosystem. Over the decades of operation of such systems, the geochemical leveling of concentrations in small water bodies and collectors has occurred (Table 1) [6]. This is due, on the one hand, to underground feeding by groundwater of the same composition, and small rivers and open collectors in the earthen channel, and, on the other hand, comparable flows of rivers and collectors.

Table 1 - Chemical composition of water in the main canal and collectors before discharge into a water body

Indicator	Unit of measure	Main channel NDMK	The beginning of the irrigation season (sampling date 05.14.2019)					End of the irrigation season(date of sampling 09.06.19)				
			K-3	LS-2	MKL-7	CS	BG-MS-4	K-3	LS-2	MKL-7	CS	BG-MS-4
1 pH	pH units	8,15	7,8	8,2	7,9	7,8	7,7	8,0	7,9	7,8	8,1	8,1
2 Suspended substances	mg/dm³	4,8	4,6	4,6	4,6	4,8	5,8	8,8	7,6	6,4	5,6	5,2
3 Mineralization	mg/dm³	649	1414	1182	1397	1129	844	770	960	1194	733	629
4 Chlorides	mg/dm³	80,0	333	155	160	167	96,6	123	107	143	113	90
5 Sulfates	mg/dm³	159,0	345	345	503	319	257	195	266	398	177	142
6 Hydrocarbonates	mg/dm³	223	307	332	336	307	243	225	291	291	225	214
7 Calcium	mg/dm³	64,9	128	100	136	140	84,2	84,2	129	132	63,3	64,1
8 Magnesium	mg/dm³	26,3	75,4	60,8	79,0	36,5	31,6	31,6	23,9	31,6	29,7	24,8
$Na^+ + K^+$	mg/dm³	95,8	225,6	240,2	183	159,5	131,6	111,2	143,1	198,4	125	94,1
9 Hardness	mmol/dm³	5,40	12,60	10,0	13,30	10,0	6,80	6,8	7,6	9,2	5,6	5,24
10 Iron total	mg/dm³	0,10	0,18	0,11	0,12	0,14	0,12	0,28	0,16	0,17	0,18	0,13
11 Copper	mg/dm³	<0,0006	0,0007	<0,0006	0,0009	0,0008	0,0010	0	0,0002	0,0035	0,0039	0,0021
12 Zinc	mg/dm³	0,0007	<0,0005	0,0034	0,0027	0,0028	0,0012	0,0005	0	0	0,0004	0,0005
13 Petroleum products	mg/dm³	not found	not def.	not def.	not def.	not def.	not def.	0,006	0,007	0,010	0,009	0,009

An important factor influencing DWW hydrochemistry is the chemical composition of the water supplied for irrigation and maintenance of the water level in the collector from the main canal, as well as the type of soil.

In the considered natural and technical system, a regional hydrochemical circulation arises (Fig. 1)
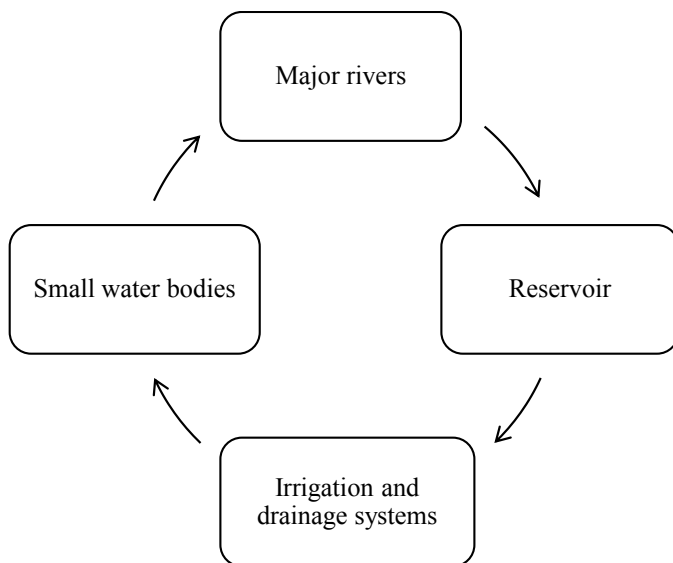
Figure 1 – Scheme of the hydrochemical water cycle in irrigated agricultural landscapes

This diagram shows that the main link that can affect the hydrochemical regime of natural water bodies is irrigation and drainage systems (primarily the collector-drainage network).

Comparison of water quality in the studied collectors and natural water bodies (2019) according to the limiting pollution factor (Kpz) showed insignificant differences in water quality (Table 2) [7].

Table 2 – *Coefficient of maximum water pollution in the studied collectors and water bodies at the place of DWW release.*

Collector name	Wpc (2019)	Water quality class	Name of the water body	Wpc five-year average	Water quality class	Criteria for assessing water quality by Wpc (according to V.V. Shabanov)
K-3	0,807	3, moderately polluted	Yerik Beshenyy	0,43	3, moderately polluted	1 Very clean≤-0,8
LS-2	0,537	3, moderately polluted	R.Solenaya	0,108	3, moderately polluted	2 Clean -0,8-0
MKL-7	0,964	3, moderately polluted	Kolodezki tract	0,178	3, moderately polluted	3 Moderately polluted 0-1
CS	0,353	3, moderately polluted	R. Don (174 km from the mouth)	0,204	3, moderately polluted	4 Polluted 1-3
BG-MS-4	0,05	3, moderately polluted, close to 2, clean	Kostylevsky pond	0,01	2, clean	5 Dirty 3-5

Studying the hydrochemistry of open collectors in the earthen channel, it was found that the chemical composition of water in the collectors outside the irrigation period under conditions of insufficient precipitation depends entirely on the underground supply, in the irrigation period - on the chemical composition of the irrigation water. In addition, the moisture-loving vegetation growing along the coastal slopes (cattail, sedge, etc.) plays the role of natural filters and sorbents for both nutrients and salt-forming ions. Consequently, an open collector-drainage network in an earthen bed causes minimal damage to the hydrochemical regime of the seineless geosystem.

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国际科学大会的材料

2020年9月16日。中国北京