

L a s e r
t h e r a p y
for joint and
muscle pain

S.V. Moskvina, S.B. Kisselev



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**Laser therapy
for joint and muscle pain**

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Pain is a concept that is clinically and pathogenetically complex and heterogeneous. It varies in intensity, localization and subjective manifestations (shooting, pressing, pulsating, pricking, cutting, aching, etc.), can be permanent or periodic, which is largely due to localization and what causes it.

Some well-recognised types of pain include muscle or joint-muscle pain. An example of this type of pain is fibromyalgia, a rheumatic disease of unknown etiology, is characterized by generalized muscle weakness and painful palpation in limited areas of the body, designated as trigger points. Effective methods of treatment of patients with this disease have not yet been developed. Some medications allow the patient some form of short-term relief, however, even this is not always the case.

Using a complex approach, which involves a wide range of laser therapy methods, it allows the human body to restore itself and any abnormalities in the functioning of various organs and systems, which, as well as providing direct analgesia, ensures the elimination of the causes of the disease. In addition, laser therapy methods are simple and safe, and unlike analgesics do not cause side effects, as well as there being no contraindications.

Laser illumination doesn't only affect one link of the painful reception, but essentially the whole hierarchy of mechanisms in the appearance of pain. Due to this, the curative effect persists for a long period of time. This "versatility" predetermines the exceptional effectiveness of laser therapy, all while using adequate techniques and appropriate equipment. Laser therapeutic devices in the LASMIK series have a frequency of up to 10.000Hz, and a unique set of laser emitting attachments and nozzles. These are the most suitable for implementing methods of pain management.

The book is intended for specialists in rehabilitation, rheumatologists, traumatologists, general practitioners and physiotherapists.

About the authors

Sergey Vladimirovich Moskvin – Doctor of Biological Sciences, PhD of Technical Sciences, Leading Researcher of The Federal State-Financed Institution "State Scientific Centre of Laser Medicine under the Federal Medical Biological Agency" of Russia, Moscow, author of more than 500 scientific publications, including more than 50 monographs and 30 copyright certificates and patents; email: 7652612@mail.ru, website: www.lasmik.ru

Serguei Borisovich Kisselev – Founder and Chief Medical Officer of Medical Companies Advanced Rural Health, KRISS and LASMIK Australia, FRACGP, President of the Australian Association of Musculoskeletal Medicine (AAMM), member of the Australian Association of Laser Medicine AMLA; email: smc.gpnw@gmail.com

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INTRODUCTION

Chronic pain (unrelated to cancer) affects approximately 10–20% of US residents, 45% of those spending 85–90 billion dollars to receive annual treatment only to *manage* their pain [Gitlin M.C., 1999]. Most of these problems are due to diseases of the musculoskeletal system (MSS), in particular fibromyalgia (FM), which affects around six million Americans, four million of whom are women [Bennett R., 2016].

According to the Research Institute of Rheumatology, there are more than four million officially registered patients with arthrosis in Russia. However, there are at least twenty million Russians who periodically visit doctors with diseases of the MSS, and the amount of juvenile arthritis cases increase. Despite a significant number of drugs as well as non-pharmacological methods of treatment, their effectiveness is very doubtful. In addition, long-term use of analgesics, sedatives and non-steroidal anti-inflammatory drugs (NSAID's – commonly used for treatment) leads to the development of side effects, aggravating the severity of the condition of patients [Bochkova I.A., 1998]. This is not ideal, considering that it is necessary to constantly take this medication.

Laser therapy (LT) is one of the more common methods of physiotherapy, which is the modern stage in the development of heliotherapy and light therapy. At the end of the 19th century, Nobel laureate N.R. Finsen proved that it is possible to significantly increase the effectiveness of light therapy by using “special” lamps instead of sunlight, so that one is able to control their power, area, exposure time and is also able to allocate the desired spectrum of light. In the early 1960's, lasers appeared on the market. They were sources of monochromatic light (therefore, it is not necessary to use light filters to isolate a part of the spectrum), whose energy parameters were much easier to control. These qualities led to the emergence of a fundamentally new direction – laser therapy, which is characterized by its higher efficiency and universality [Moskvin S.V., 1997].

Exposure to low-intensity laser illumination (LILI) causes a reaction in the body, and as a result, homeostasis (which was disturbed beforehand) is restored, resulting in the recovery of the patient. After absorption of laser light in the cells, Ca^{2+} -dependent processes are the first to activate, launching numerous secondary reactions at the tissue and organism level [Moskvin S.V., 2008, 2014, 2016]. These processes are discussed in detail in the relevant chapters of the book as a justification for the possibilities of using laser therapy, which is successfully used in almost all areas of modern medicine: obstetrics and gynaecology [Fedorova T.A., et al., 2009], andrology and urology [Ivanchenko L.P., et al., 2009; Mufaged M.L., et al., 2007], neurology [Kochetkov A.V., Moskvin SV, 2004; Kochetkov A.V., et al., 2012], otorhinolaryngology [Nasedkin A.N., Moskvin S.V., 2011], paediatrics [Moskvin S.V., et al., 2010⁽¹⁾], dentistry [Amirkhanyan A.N., Moskvin S.V., 2008; Moskvin S.V., Amirkhanyan A.N., 2011] et al.

Correlated and combined methods of laser therapy are developing quite rapidly. Methods such as laser phoresis [Moskvin S.V., Konchugova T.V., 2012; Moskvin S.V., et al, 2010; Khadartsev A.A., et al., 2016], laser-vacuum massage [Moskvin SV, Gorbani NA, 2010, Moskvin S.V., et al., 2014] and High Frequency laser therapy [Brehov E.I., et al., 2007; Moskvin S.V., Khadartsev A.A., 2016]. These are all the pre-

requisites for the application of these methods and in the treatment of patients with musculo-skeletal diseases, primarily in the aspect of the problem of pain management.

There are several common methods of laser illumination which are used the most often:

External illumination:

- projection of the internal organs;
- on immunocompetent organs;
- at the acupuncture points (AP);
- paravertebral;
- at trigger points (TP), painful points (PP) and painful areas (PA).

On large blood vessels: intravenous laser blood illumination (ILBI) and non-invasive laser blood illumination (NILBI); [Moskvin S.V., 2016].

It is shown that only their complex and competent use effectively treats patients with various diseases and pathological conditions, the most frequent manifestation of which is severe pain.

There are several common methods of laser illumination which are used the most often: externally, projecting on to the internal and immunocompetent organs, on to large blood vessels, intravenously, paravertebrally, on to acupuncture points (AP) and trigger points (TP) [Moskvin S.V., 2016]. It is shown that only their complex and competent use effectively treats patients with various diseases and pathological conditions, the most frequent manifestation of which is severe pain.

This book presents the pathogenesis of pain syndromes, the details are considered as mechanisms that cause painful sensations, as well as the sources that cause their occurrence. This is presented in the context of the known mechanisms and the influence of LILI on these processes. Features of pains that are localised in the soft tissues (class M79 according to ICD-10), often referred to as joint-muscle pains, are considered even more so, especially in the presence of a clinical picture associated with inflammatory processes and/or injuries in the joints or ligaments. Medical regimens including correlated and combined laser therapy methods are proposed.

Some terms in the book are used equally, although they have significant semantic differences, for the explanation of which the relevant comments are given.

Classification of diseases.

Diseases of soft tissue, not elsewhere classified (M79).

Excluded: pain in soft tissues, psychogenic (F45.4).

Rheumatism, unspecified M79.0.

Excluded: fibromyalgia (M79.7), palindromic rheumatism (M12.3).

Mialgia M79.1.

Excluded: myositis (M60.-).

Neuralgia M79.2.

Excludes: mononeuropathy (G56–G58), radiculitis – OBD (M54.1), shoulder (M54.1), lumbosacral (M54.1), sciatica (M54.3–M54.4).

Pain in the limb M79.6.

Fibromyalgia (FM) M79.7.

Myofascial pain syndrome (MFPS) has no code for ICD-10 as a separate disease, but it is mentioned in the book, mainly when referring relevant studies, since it is often found in specialized articles and studies.

Particular attention is paid in the book to FM, as well as to the MFPS, as a special case of the disease, therefore the terms are used almost equally. The existing peculiarities and differences in the etiopathogenesis, which authors of various studies draw attention to, are mostly given without any correction, since a common decision among specialists has not been worked out with respect to many facts. Moreover, it does not have any influence on the development of laser therapy methodology.

It should be noted that the trigger points themselves, which are often recognized as one of the main diagnostic criteria of FM, are still very controversial. Is it possible to repeatedly determine TP's? Do they have objective criteria for manifestation, such as spontaneous electromyographic activity or specific inflammation? Can they be visualized using new ultrasound techniques? Is fibromyalgia a syndrome of multiple TP's or is it a focal muscular pain due to central stimulation? Opinions on this are often directly opposed [Bennett R.M., Goldenberg D.L., 2011].

We adhere to the point of view that TPs, determined under the MFPS, cannot be distinguished clinically or pathophysiologically from painful zones – which are characteristics of FM – and any peripheral pain is, to some extent, always associated with the central mechanisms of its regulation. This is the reason for the complex approach recommended by a majority of authors to solve the problem of pain management in general, in particular the pain syndromes in FM.

In the opinion of most specialists, FM is a nonspecific (the association with other pathologies is poorly understood) syndrome of chronic muscle pain. Such patients are easily recognized by the characteristic prevalence and localization of pain in the body. Over a long period of observation, we came to the unequivocal conclusion that treatment of patients with FM should be individual and requires a holistic approach; it takes time, empathy and interaction with doctors of different specialties. Ensuring the effective management of such patients is often a real test of the professionalism of the doctor [Bennett R., 2016; Bennett, R.M., 1996].

The methodology of laser therapy does not stand still. It is actively developing, therefore many known methods which are offered in clinical recommendations, but were developed many years ago, do not satisfy modern requirements. New devices have appeared and with them, new opportunities to greatly expand the prospects for creating highly effective methods of treatment.

This book is a comprehensive analysis of many Russian and international publications, in order to develop a well-established methodology for laser therapy for joint-muscle pain, taking into account its own clinical experience. To some extent, this has already been done, a considerable amount of long-term clinical practice has accumulated with experience, allowing both specialists and patients to appreciate the effectiveness and prospects of laser therapy.

Unfortunately, pain syndromes such as cervicalgia, lumbosialgia, variants of headaches, temporomandibular joint dysfunction (TMD), etc. are not shown in this book. These topics will be discussed in the relevant thematic publications.

This book is intended for specialists in the field of orthopaedics, sports medicine and rehabilitation, rheumatologists, general practitioners and physiotherapists. Questions, comments and comments for the authors will gladly accept by email: 7652612@mail.ru, smc.gpnw@gmail.com.

PRIMARY AND SECONDARY MECHANISMS OF THE BIOMODULATING ACTION OF LOW-INTENSITY LASER LIGHT

More details on the primary mechanism of the biological, or, as it is customary to say, biomodulatory action (BA) of LLLT, as well as the proof of the model proposed by us, can be found in the first two volumes of the series of books: “Effective Laser Therapy” [Moskvin S.V., 2014, 2016], which is available to download for free at <http://lasmik.ru> (in Russian).

In this chapter, as well as in some other sections of the book, we will present studies on the secondary processes that occur when laser light is absorbed by living cells and biotissues, knowledge of which is extremely important for the clinical application and understanding of the methodology of laser therapy, especially when applying to the problem of pain and trophic disorders.

We have chosen a systematic approach to analyse the data for studying the mechanisms of the BA of LILI, for which a part of the whole organism is conventionally allocated, united by the type of anatomical structure or type of functioning. However, each part is considered exclusively in terms of its interaction as a unified system. The key point of this approach is the definition of a *system-forming factor* [Anokhin P.K., 1973]. The scientific study was analysed, first of all, concerning the study of the BA mechanisms, the practice of using LLLT in clinical medicine, as well as modern concepts of biochemistry and physiology as a living cell of the structure of regulation of human homeostasis as a whole. Based on the obtained data, some fundamentally important conclusions were drawn, which were confirmed in numerous experimental and clinical studies [Moskvin S.V., 2008, 2008 (1), 2014].

It is shown that as a result of the absorption of LLLT energy, this energy transforms into biological reactions at all levels of a living organism, which in turn is regulated in many ways – this is the reason for the extraordinary versatility of the effects manifested from the impact. In this case, we are only dealing with the external launching of self-regulation and self-repair of disturbed homeostasis. Therefore, there is nothing surprising in the universality of laser therapy: *this is the result of eliminating pathological fixation of the organism beyond the limits of normal physiological regulation.*

Photobiological processes can be schematically represented as the following sequence: after the absorption of photons by acceptors whose absorption spectrum coincides with the wavelength of the incidental light, biochemical or physiological reactions characteristic (specific) for these absorbing elements are triggered. But for laser-induced bioeffects, it looks as if there are no specific acceptors or responses of biological systems (cells, organ, organism), the interaction is completely non-specific. This is confirmed by the relative non-specificity of the wavelength-effect relationship, the response of the living organism to one degree or another takes place within the entire known spectral range, from the ultraviolet (325nm) to the far infrared region (10.600nm) [Moskvin S.V., 2014; Moskvin S.V., 2017].

The absence of a specific spectrum of action can be explained only by the thermodynamic nature of the LLLT interaction with the living cell, when the temperature gradient arising at the absorption centres causes the triggering of various systems of the physiological regulation. We can assume that the primary link is the intracellular calcium stores capable of releasing Ca^{2+} under the influence of many external factors [Berridge M.J. et al., 2000]. There are enough arguments to support this theory, but due to the limitation of the size of the book we only give one: all known effects of laser-induced biomodulation are secondary and Ca^{2+} -dependent [Moskvin S.V., 2003, 2008, 2008 (1)].

We must also discuss energy patterns, which are even more surprising than spectral patterns. We must look at some basic concepts, foundations and axioms of laser therapy. The most famous of them is the dependence of results on the presence of the optimum “energy density (ED) – effect”, which is sometimes called the “biphase” [Huang Y.-Y. et al., 2009], i.e. the desired result is only achieved with the optimum ED of exposure. A decrease or increase of this value (even within a very narrow range) leads to a decrease in the effect, to its complete disappearance or even to an inverse response.

This is the fundamental difference between the BA of LLLT and the photobiological phenomena, where the dependence on the ED is linearly increasing over a wide range of characteristics. For example, the more sunlight, the more intense the photosynthesis and therefore an increase in plant production of oxygen and energy. Does it directly contradict the biphasic nature of the biological effect of the LLLT laws of photobiology? Not at all! This is only a special case in the manifestation of the physiological law of dependence of the response on the strength of the acting stimulus. In the “optimum” phase, after reaching the threshold level as the stimulus strength increases, the response of cells and tissues increases and the reaction reaches a maximum (or plateau). A further increase in the stimulus force leads to an inhibition of the reactions of cells and the organism, the inhibition of the reactions or a state of parabiosis develops in the tissues [Nasonov D.N., 1962].

In order to effectively influence LLLT, it is necessary to provide both optimal power and power density (PD), i.e., it is important to distribute light energy over the area of cells *in vitro* and the area and/or volume of biological tissues in animal and clinic experiments.

Exposure (time of exposure) per zone, which should not exceed 300 seconds (five minutes), except in some variations, such as the method of intravenous laser blood-illumination (which can up to 20 minutes). This is extremely important to remember!

Multiplying the exposure on the PD produces a power density per unit time, or ED. It is a derivative quantity that does not play any role, but is often mistakenly used in some studies under the name “dose”, which is absolutely unacceptable.

For pulsed lasers (pulse power more often within the range of 10–100W, duration of the light pulse 100–150ns), as the pulse repetition frequency increases, the average power, i.e., the effect of the ED, increases proportionally.

It is interesting that the ED for pulsed lasers ($0.1\text{J}/\text{cm}^2$) is ten times smaller than for a continuous LLLI ($1\text{--}20\text{J}/\text{cm}^2$) for similar experimental models [Zharov V.P., et

al., 1987; Nussbaum E.L., et al., 2002; Karu T. et al., 1994]. This indicates a greater efficiency of the pulsed regime. There is no analogue of this pattern in photobiology.

Another interesting fact should be noted – the nonlinear dependence of the BA of LLLT on the exposure time. This can easily be explained by the periodicity of waves of increased concentration of Ca^{2+} , propagating in the cytosol after laser activation of intracellular calcium depots. And for completely different types of cells, these periods are completely identical and are strictly 100 and 300 seconds (Table 1). Clinical studies confirming the effectiveness of laser therapy methods when using such an exposure are hundreds of times greater. We draw attention to the fact that the effect is observed in a very wide wavelength range, therefore, intracellular calcium depots localized in different parts of the cell have a different structure.

Table 1

**Optimal exposure of 100 or 300 seconds
for maximum *in vitro* effect**

Type of Cell	Results	Wavelength, nm	Link to supporting study
E. coli, S. aureus	Proliferation	467	Podshibyakin D.V., 2010
Hypocampus	Epileptiform activity	488	Walker J.B. et al., 2005
Fibroblasts	Proliferation	633	Rigau J. et al., 1996
Fibroblasts	Increase in Ca^{2+}	633	Lubart R. et al., 1997 ⁽¹⁾ ; 2005
Keratinocytes	Increase in IL-1 α and IL-8 production and expression of mRNA	633	Yu H.S. et al., 1996
Macrophages	Proliferation	633	Hemvani N. et al., 1998
Fibroblasts, E. coli	Proliferation	660	Ribeiro M.S. et al., 2010
Human neutrophils	Increase in Ca^{2+} concentration in the cytosol	812	Løvschall H. et al., 1994
Human buccal epithelial cells	Proliferation	812	Løvschall H., Arenholt-Bindslev D., 1994
E. coli	Proliferation	890	Zharov V.P. et al., 1987
Myoblastes C2C12	Proliferation, vitality	660, 780	Ferreira M.P.P. et al., 2009
HeLa	Mitotic Activity	633, 658, 785	Yang H.Q. et al., 2012
E. coli	Proliferation	633, 1064, 1286	Karu T. et al., 1994

When demonstrating that the activation of the mitochondrial function is a secondary process, only as a result of an increase in the concentration of Ca^{2+} in the cytosol, it must be noted that the results of the corresponding graphs come from one single study (Figure 1) [Alexandratou E. et al., 2002].

The most important thing is the fact that the concentration of Ca^{2+} increases solely due to intracellular depots (where calcium ions are re-injected after the end of the physiological cycle in 5–6 minutes), rather than as a result of the intake of ions from outside, as many believe [Breitbart H. et al., 1996; Colver G.B., Priestley, G.C., 1989;

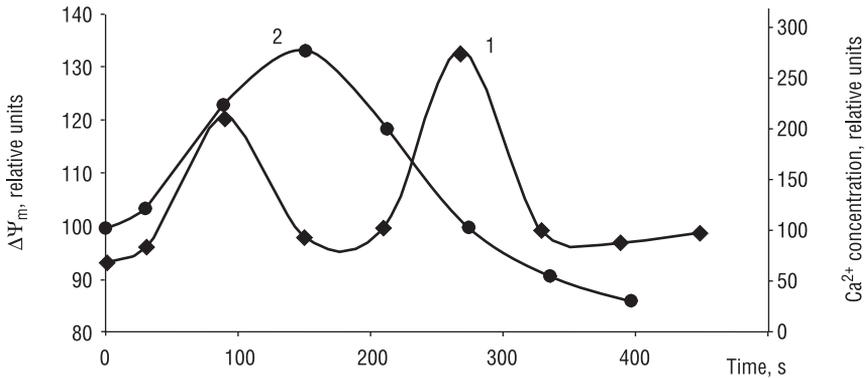


Fig. 1. Changes of Ca^{2+} concentration (1) in cytosol and mitochondria redox potential $\Delta\Psi_m$ (2) after laser stimulation (647nm, 0.1mW/cm², exposure 15s) on human foreskin fibroblasts (Alexandratou E. et al., 2002)

Friedmann H., Lubart R., 1996; Lubart R. et al., 1997; Smith K.C., 1990; Webb C. et al., 1998]. Firstly, there is no correlation between the level of ATP in cells and transport from outside of Ca^{2+} to the cell, activation of the mitochondrial function is realized only by increasing the concentration of Ca^{2+} from intracellular stores [Breitbart H. et al., 1990; Singh J.P. et al., 1983]. Secondly, the removal of calcium ions from the serum does not delay the increase in the Ca^{2+} concentration in anaphase during cell cycle [Tombes R.M., Borisy G.G., 1989], i.e., the activation of cell proliferation under the influence of LILI is not associated with extracellular calcium, membranes specifically dependent pumps, etc. These processes are only important when exposed to cells that are in the whole body, and are secondary.

The patterns shown above are easily explained if the mechanisms of the BA of LLLT are arranged in this kind of sequence: as a result of LILI, a thermodynamic disturbance arises inside the cell (*temperature gradient*), resulting in the activation of the intracellular depot, release of calcium ions (Ca^{2+}) in the short-term (up to 300 seconds) an increase in their concentration, followed by the development of a cascade of responses at all levels, from cells to the organism as a whole: activation of the mitochondria, metabolic processes and proliferation, the normalization of the immune and vascular systems, the inclusion of an analgesic effect in the Autonomic Nervous System (ANS) and the Central Nervous System (CNS) processes etc. (Figure 2) [Moskvin S.V., 2003, 2008, 2014, 2016].

This such approach makes it possible to explain the nonlinear characteristic of the “ED-effect” and “exposure-effect” dependences by the features of the operation of intracellular calcium depots, and the absence of the action spectrum by the non-specificity of their inclusion.

Let us repeat that the foregoing refers to “laser” rather than “photo” (biomodulation), i.e., only for monochromatic light and in the absence of a specific influence (for example, bactericidal action).

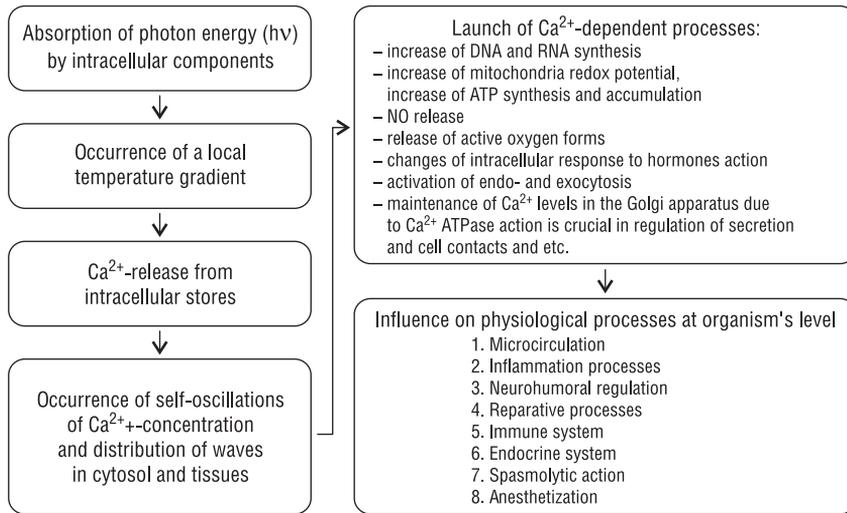


Fig. 2. The sequence of development of biological effects after the use of LILI (mechanisms of biological and therapeutic action)

The most important thing in correctly understanding the mechanisms of the BA of LLLT is the opportunity to develop and optimize laser therapy techniques, to understand the principles and conditions for effective applications of the method.

The effect dependent on the frequency of modulation, monochromaticity, polarisation, etc. forces us to consider these patterns from the standpoint of not-quite-classical photobiology. Here, in order to characterize the supporters of the “acceptors” static approach of studying the mechanisms of the BA of LILI, it is appropriate to quote the words of American writer G. Harrison: “The facts were laid out on the shelves. Then they analysed the most complicated closed system with such elements as positive and negative feedback, or variable commutation. And the entire system is in a dynamic state due to continuous homeostatic correction. It’s no wonder that they did not get anything done.” So photobiologists with a similar approach to research did not understand anything in the mechanisms of the BA of LILI.

So how do biological processes induced by laser light develop? Is it possible to trace the entire chain, from the absorption of photons to the recovery of the patient, to fully and reliably explain the available scientific facts and on their basis to develop the most effective methods of treatment? In our opinion, there are many reasons for an affirmative answer to these questions, of course, within the framework of the limited general knowledge in the field of biology and physiology.

The mechanisms of the biological (therapeutic) action of low-intensity laser light on any living organism must only be considered from the position of the community of nature both the acting light energy and the structure of living matter. Fig. 2 shows the main sequence of reactions, starting from the primary act of absorbing the photon and ending with the reaction of the various body systems. This scheme can only be supplemented with details of the pathogenesis of a particular disease.

How does it all begin? Proceeding from the fact that low-intensity laser light causes the corresponding *in vitro* effects in a single cell, it can be assumed that the initial starting moment – when acting on the biotissue – is the absorption of LILI by intracellular components. We will try to figure out which ones.

In the facts presented above and those obtained by T. Karu et al., (1994), the data convincingly proves that such regularities can only be the result of the thermodynamic processes that take place during the absorption of laser light by any, that is, any, intracellular components. Theoretical estimates show that under the influence of LILI, local “heating” of acceptors by tens of degrees is possible. Although the process lasts for a short amount of time – less than 10–12 seconds, this is quite enough for very significant thermodynamic changes, both in the chromophores group directly and in the surrounding regions, which leads to significant changes in the properties of the molecules, and is the starting point of the laser-induced reaction. We emphasize once again that any intracellular component that absorbs at a given wavelength, including water with a continuous absorption spectrum, can act as an acceptor. That is, the initial starting moment of the BA of LILI is not a photobiological reaction per se, but the appearance of a local temperature gradient, and we are dealing with a thermodynamic, rather than a photobiological effect (in the classical sense of the term), as previously thought. This is a fundamentally important point.

It should be understood that the term “temperature gradient” does not mean a change in temperature in the conventional, everyday sense. We are talking about the thermodynamic process and terminology from the corresponding section of physics – thermodynamics, which characterizes the change in the state of the vibrational levels of macromolecules and exclusively describes the energy processes [Moskvin S.V., 2014, 2016]. Such “temperature” cannot be measured with a thermometer.

However, it is the “absence of direct experimental evidence of local intracellular temperature increase” that is the main argument in criticizing our theory [Ulashchik V.S., 2016]. Notice, however, V.S. Ulaschik, (2016) regarding the fact that the result of this process cannot only be the release of calcium ions, should be recognized as fair. Indeed, there is, albeit a very limited, list of identified regularities that are difficult to explain only by Ca^{2+} – dependent processes, this has yet to be studied.

Nevertheless, the conclusions from our theory have already made it possible to improve the effectiveness of laser therapy methods qualitatively, their stability and reproducibility, which is already enough for it to be well recognized (although we are not suggesting that we will not continue to further develop the methodology). It is also absolutely impossible to agree with the opinion of the highly-respected specialist [Ulaschik V.S., 2016] that they have the right to the existence of a “theory” only in the presence of certain “experimental data”, often very questionable and misinterpreted, the conclusions from which are harmful for clinical practice. For example, the consequence of such hypotheses is the impossibility of using LILI for the laser therapy with a wavelength in the range of 890–904nm. And what do tens of thousands of specialists need to do when they have successfully used such laser light for more than 30 years, consider it to be the most effective and receive excellent results of treatment? Refuse the reality to please the ambitions of individuals?

There are no reasonable arguments against the thermodynamic nature of LILI interaction at a cellular level, otherwise it is simply impossible to explain the incredibly wide and almost continuous spectrum of action (from 235 to 10.600nm), therefore, in the part of the primary process, we will continue to adhere to our concept.

With insignificant local thermodynamic perturbations, insufficient enough to transfer the molecule to a new conformational state, the geometry, the configuration of the molecules, can change a lot comparatively. The structure of the molecule is “led”, which is facilitated by the possibility of rotations around the single bonds of the main chain, not very strict requirements for linearity of hydrogen bonds, etc. This property of macromolecules decisively influences their functioning. For an efficient conversion of energy, it is sufficient to excite such degrees of freedom of the system that slowly exchanges energy with thermal degrees of freedom [Goodwin B., 1966]. Presumably, the ability to direct conformational changes, i.e., movements under the influence of local gradients, is a distinctive feature of protein macromolecules, and the required relaxation changes may well be caused by laser light of “low” or “therapeutic” intensity (power, energy) [Moskvin S.V., 2003⁽²⁾].

The functioning of most intracellular components is closely related not only to the nature of their conformations, but most importantly, to their conformational mobility, which depends on the presence of water. Due to hydrophobic interactions, water exists not only as a bulk phase of a free solvent (cytosol), but also in the form of bound water (cytogel), the state of which depends on the nature and localization of the protein groups with which it interacts. The lifetime of loosely bound water molecules in such a hydrated shell is small ($t \sim 10^{-12}$ – 10^{-11} seconds), but it is much larger near the centre ($t \sim 10^{-6}$ seconds). In general, several layers of water can be held firmly around the surface of the protein. Small changes in the number and state of a relatively small fraction of the water molecules forming the hydrate layer of the macromolecule leads to abrupt changes in the thermodynamic and relaxation parameters of the entire solution as a whole [Rubin A.B., 1987].

Explaining the mechanisms of the BA of LILI from a thermodynamic position makes it possible to understand why the effect is achieved when it is exposed to *laser* light, and the most important is its property, such as monochromaticity. If the width of the spectral line is significant (20–30nm or more), that is, commensurate with the absorption band of the macromolecule, then such light initiates the oscillation of all energy levels and only a weak, 1/100th of a degree, “heating” of the *entire molecule* will occur. However, when light with a minimum width of the spectral line, characteristic in LILI (less than 3nm), this will cause a full effect, the temperature gradient increases by tens of degrees. In this case, all the laser light energy will be released (conditionally speaking) on a small local part of the macromolecule, causing thermodynamic changes, increasing the number of vibrations with higher energy, sufficient to trigger a further physiological response. Conducting a conditional analogy, the process can be represented as follows: when concentrating a magnifying glass of sunlight on a point, you can set fire to paper, while when light is scattered over an entire area, only a mild heating of the surface occurs.

A consequence of the photoinduced “behaviour” of macromolecules is the release of calcium ions from the calcium depot into the cytosol, and the propagation of waves of increased concentration of Ca^{2+} along and between cells. This is the main, key moment of the primary stage of development of the laser-induced process. Together with the photon absorption act, the appearance and propagation of waves of an increased concentration of calcium ions can be determined precisely as the primary mechanism of the BA of NILI.

The first possible participation of calcium ions in laser-induced effects was suggested by N.F. Kuznetsov. Gamaleya (1972). Later, it was confirmed that the intracellular concentration of calcium ions in the cytosol under the influence of LILI increases by many times [Smolyaninova N.K. et al., 1990; Tolstykh P.I. et al., 2002; Alexandratou E. et al., 2002]. However, in all studies, these changes were noted only in conjunction with other processes, and did not stand out in any special way. Our studies were the ones that first suggested that an increase in the concentration of Ca^{2+} in the cytosol is precisely the main mechanism that subsequently launches secondary laser-induced processes. It should also be noted that all the physiological changes that occur as a result of this at various, *calcium-dependent* levels, [Moskvin S.V., 2003].

Why do we pay attention to calcium ions? There are several reasons for this:

1. Calcium is found to be presented in the most specific and non-specifically bound state both in cells (99.9%) and in blood (70%) [Murray R. et al., 2009], i.e., in principle, there is the possibility of a significant increase in the concentration of free calcium ions, and this process is provided by over a dozen different mechanisms. Furthermore, in all living cells there are specialized intracellular depots (sarco- or endoplasmic reticulum) for storage of only calcium in the bound state. The intracellular concentration of other ions and ionic complexes is exclusively regulated by transmembrane ion fluxes.
2. The extraordinary versatility of the mechanisms of regulation of Ca^{2+} in many physiological processes, in particular: neuromuscular stimulation, blood coagulation, secretion processes, maintenance of membrane integrity and deformability, transmembrane transport, numerous enzymatic reactions, release of hormones and neurotransmitters, intracellular action of a number of hormones, etc. [Grenner D., 1993⁽¹⁾].
3. The intracellular Ca^{2+} concentration is extremely small – 0.1–10 $\mu\text{m/L}$, so the release of even a small absolute amount of these ions from the bound state leads to a significant relative increase in the Ca^{2+} concentration in the cytosol [Smolyaninova N.K., et al., 1990; Alexandratou E. et al., 2002].
4. The role of calcium in the maintenance of homeostasis is becoming more apparent every day. For example, Ca^{2+} -induced changes in the mitochondrial membrane potential and an increase in intracellular pH lead to an increase in ATP production, and ultimately stimulates proliferation [Karu T., 2000; Schaffer M. et al., 1997]. Stimulation with visible light leads to an increase in the level of intracellular cAMP almost synchronously with a change in the intracellular Ca^{2+} concentration in the first few minutes after exposure [Daniolos A. et al., 1990], thus contributing to the regulation by calcium pumps.

5. It is important to note that the organization of the cell itself ensures its homeostasis, in most cases precisely through the influence of calcium ions on energy processes. A specific coordinating mechanism is the general cell oscillatory circuit: Ca^{2+} cytosol – calmodulin (CaM) – a system of cyclic nucleotides [Meerson F.Z., 1984]. Another mechanism is also involved through Ca^{2+} -binding proteins: calbodyne, calretinin, parvalbumin and effectors such as troponin C, CaM, synaptotagmine, S100 proteins and annexins, which are responsible for activating Ca^{2+} -sensitive processes in cells [John L.M., et al., 2001; Palecek J. et al., 1999].
6. The presence of various vibrational contours of changes in the concentrations of active intracellular substances is closely related to the dynamics of the regulation and release of the content of calcium ions. The point is that the local increase in Ca^{2+} concentration does not end with a uniformly diffused distribution of ions in the cytosol, or by the inclusion of mechanisms for pumping surpluses into intracellular stores, but is accompanied by the propagation of waves of increased Ca^{2+} concentration inside the cell, causing numerous calcium-dependent processes [Alexandratou E. et al. 2002; Tsien R.Y., Poenie M., 1986]. Calcium ions released by one cluster of specialized tubules diffuse to neighbouring ones and activate them. This hopping mechanism allows the initial local signal to trigger global waves and fluctuations in Ca^{2+} concentrations [Berridge M.J., et al., 2000].
7. Sometimes Ca^{2+} waves are very limited in space, for example, in the amakrinovyh cells of the retina, in which local signals from dendrites are used to calculate the direction of motion [Euler T. et al., 2002]. In addition to such intracellular waves, information can propagate from cell to cell through intercellular waves, as described for endocrine cells [Fauquier T. et al., 2001], vertebrate gastrulas [Wallingford J.V. et al., 2001] and intact perfused liver [Robb-Gaspers L.D., Thomas A.P., 1995]. In some cases, intercellular waves can pass from one cell type to another, as happens in endothelial cells and smooth muscle cells [Yashiro Y., Duling B.R., 2000]. The act of such propagation of Ca^{2+} waves is very important, for example, for explaining the mechanism of generalization of laser action during the healing of a large wound (for example, a burn) with a local effect of LILI.

So, what happens after the waves of increased concentration of Ca^{2+} began to spread under the influence of LILI in the cytosol of the cell and between groups of cells at a tissue level? To answer this question, it is necessary to consider what changes LILI causes at the organism level. Laser therapy has become widespread in almost all fields of medicine due to the fact that LILI initiates a wide variety of biochemical and physiological responses that represent a complex of adaptive and compensatory responses that result from the realization of primary effects in the tissues, organs and a complete living organism, as well as aiming at its recovery:

- 1) activation of the cell metabolism and an increase in their functional activity;
- 2) stimulation of reparative processes;
- 3) anti-inflammatory effect;

- 4) activation of the microcirculation of blood and an increase of level of trophic maintenance of tissues;
- 5) anaesthesia;
- 6) immunomodulatory action;
- 7) the reflexogenic effect on the functional activity of various organs and systems.

Here we should pay attention to two important points. Firstly, in almost each of the listed above points a priori, one-directional influence of LILI (stimulation, activation, etc.) is given. As will be shown below, this is not entirely true, and laser light can cause directly opposite effects, which is well known from clinical practice. Secondly, all these processes are Ca^{2+} -dependent! That's what no one has really ever paid attention to. Let us now consider exactly how the physiological changes take place, citing as an example only a small part of the known ways of regulating them.

The activation of the cell metabolism and the increase in their functional activity is primarily due to a calcium-dependent increase in the mitochondrial redox potential, their functional activity, and the synthesis of ATP [Karu T., 2000; Filippin L. et al., 2003; Schaffer M. et al., 1997].

Stimulation of reparative processes depends on Ca^{2+} on different levels. In addition to activating mitochondrial activity with the increasing concentration of calcium ions, protein kinases that participate in the formation of mRNA are activated [Watman N.P., et al., 1988]. Also, calcium ions are allosteric inhibitors of membrane-bound thioredoxin-reductase, an enzyme that controls the complex process of purine deoxyribonucleotide synthesis during the period of active DNA synthesis and cell division [Rodwell, V., 1993]. In addition, in the physiology of the wound process, the main fibroblast growth factor (bFGF), whose synthesis and activity depends on the Ca^{2+} concentration, is actively involved [Abdel-Naser M.B., 1999].

The *anti-inflammatory effect* of LILI and its influence on microcirculation are due in particular to the Ca^{2+} -dependent release of inflammatory mediators, such as cytokines [Uhlén P. et al., 2000], as well as Ca^{2+} -dependent vasodilator-nitric oxide (NO) – the precursor of the endothelial vessel wall relaxation factor (EDRF) [Murrey R.K., et al., 1996].

Since exocytosis is exogenous to calcium dependent processes [Carafoli E., et al., 2001], in particular the release of neurotransmitters from synaptic vesicles [Palecek J. et al., 1999], the process of neurohumoral regulation is completely controlled by the concentration of Ca^{2+} , as well as being influenced by LILI. In addition, it is known that Ca^{2+} is an intracellular mediator of the action of a number of hormones, primarily mediators of the central nervous system and autonomic nervous system [Grenner D., 1993], which also involves the participation of laser-induced effects in neurohumoral regulation.

The interaction of the neuroendocrine and immune systems has not been studied enough, but it has been established that cytokines, in particular IL-1 and IL-6, act in both directions, acting as modulators of interaction between these two systems [Roit A. et al., 2000]. LILI can influence immunity both indirectly through neuroendocrine regulation, and directly through immunocompetent cells (as proved in *in vitro* experiments). Among the early triggering moments of the blast transformation of lymphocytes is a

short-term increase in the intracellular concentration of calcium ions, which activates protein kinase, which is involved in the formation of mRNA in T-lymphocytes [Watman N.P., et al., 1988], which, in turn, is the key point of the laser stimulation of the T-lymphocytes [Manteyfel V.M., Karu T.Y., 1999]. The effect of LILI on fibroblast cells *in vitro* also leads to an increased generation of intracellular endogenous γ -interferons [Adachi Y., et al., 1999; Rosenspire A.J., et al., 2000].

In addition to the physiological reactions described above, in order to understand the picture as a whole, it is also necessary to know how laser light can affect the mechanisms of neurohumoral regulation. LILI is considered to be a *nonspecific factor*, the action of which is not directed against the causative agents or symptoms of the disease, but on increasing the body's resistance (vitality). This bioregulator is a cellular biochemical activity, and the physiological functions of the body as a whole – neuroendocrine, endocrine, vascular and immune systems.

The data of scientific research allows us to state with full confidence that laser light is not the main therapeutic agent at the organism level as a whole, but it removes obstacles, imbalances in the central nervous system (CNS) that interfere with the sanogenetic function of the brain. This is accomplished by a possible change in the physiology of tissues under the influence of laser light, both in the direction of amplification and in the direction of inhibition of their metabolism, depending mainly on the initial state of the organism and the energy density of LILI, which leads to attenuation of the pathological processes, normalization of physiological reactions and restoration of regulatory functions of the nervous system. Laser therapy, when properly applied, can restore the disturbed systemic equilibrium [Moskvin S.V., 2003⁽²⁾; Skupchenko V.V., 1991].

The comprehension of the CNS and ANS as independent structures has already ceased to suit many researchers in recent years. There are more and more facts confirming their close interactions and mutual influence. Based on the analysis of numerous scientific research data, the model of a single regulatory and supportive homeostasis system, called a neurodynamic generator (NDG) was proposed [Moskvin S.V., 2003⁽²⁾].

The main idea of the NDG model is that the dopaminergic part of the CNS and the sympathetic part of the ANS, united in a single structure, named V.V. Skupchenko (1991) by the phasic motor-vegetative (PMV) system complex, are closely related to another, mirror-like, *mutual* (the term by P.K. Anokhin) structure – the tonic motor-vegetative (TMV) system complex. The presented mechanism functions not so much as a reflex response system, but rather as a spontaneous neurodynamic generator that rebuilds its work according to the principle of self-organization.

The appearance of facts that testify to the simultaneous participation of the same brain structures in providing both somatic and vegetative regulation is difficult to perceive, since they do not fit into known theoretical constructions. However, we cannot deny what is confirmed by everyday clinical practice. This such mechanism, possessing a certain neurodynamic mobility, is not only able to provide a continuously changing adaptive adjustment of the whole range of energy, proliferative and metabolic processes, which was first suggested and brilliantly proved by V.V. Skupchenko (1991), but manages, in fact, the entire hierarchy of regulatory systems from the cellular level to the central nervous system, including endocrine and immunological changes [Mosk-

vin S.V., 2003⁽²⁾). In clinical practice, the first positive results of this approach to the mechanism of neurohumoral regulation were obtained in neurology [Skupchenko V.V., Makhovskaya T.G., 1993] with the removal of keloid scars [Skupchenko V.V., Milyudin E.S., 1994].

The terms “tonic” and “phasic” were originally formulated according to the names of the corresponding types of muscle fibres, since the first mechanism of interaction of two types of nervous systems was proposed to explain motor disorders (dyskinesias). Despite the fact that this terminology does not reflect the whole significance of NDG, we decided to keep it in memory of the pioneer of this such mechanism for regulating physiological processes – prof. V.V. Skupchenko.

Figure 3 shows the general scheme demonstrating the concept of NDG as a universal regulator of homeostasis, of course, in a “static” state, if one may say so. The main idea of such a systematization is to show the unity of all regulatory systems. This is a kind of a foothold around which the methodology of therapy and this motto is created: “The impact of unidirectional therapeutic factors” [Moskvin S.V., 2003⁽²⁾].

The scheme is rather conditional, which is emphasized by the representation of LILI as the only method for regulating the neurodynamic state. In this case, we only demonstrate the ability of the same therapeutic effect, depending on the ED for the chosen wavelength of LILI, to cause differently directed actions, which is a characteristic property of most non-specific methods of biologically significant influence, if any at all. However, laser light is the most universally therapeutic physical factor, far beyond just “one of the physiotherapy methods”. For such a conclusion, there is, of course good reason.

The proposed neurodynamic model of maintaining homeostasis allows us to re-evaluate the systemic mechanisms of mediator and vegetative regulation in a new way. The whole set of neurodynamic, neurotransmitter, immunological, neuroendocrine, metabolic, etc. processes reacting as a whole. When the vegetative balance changes at the organism level, it means that simultaneously neurodynamic restructuring covers the whole complex of the hierarchically organized system of internal regulation. Even more impressive is the fact that a local change in homeostasis at the cellular level also causes the reaction of the entire neurodynamic generator, involving – to a greater or lesser extent – its various levels [Moskvin S.V., 2003⁽²⁾]. Details of the functioning of such mechanism have not yet been fully studied, but over the past few years, the number of publications devoted to the study of this issue have increased in an avalanche-like fashion in international neurological journals. We still need to analyse the general patterns associated with the body’s response to external influences, some of them are already known and are actively used to improve the effectiveness of predicting the results of laser therapy.

Firstly, we draw attention to the need to use the terms “regulation” and “modulation” in relation to the BA of LLLT, and not “activation” or “stimulation”, since it is now quite clear that laser light is not a unidirectional influence factor. As we have shown, depending on the EP of the effect, it can shift the homeostasis in one direction or another. This is extremely important when choosing the energy parameters of the therapeutic effect, while simultaneously correctly assessing the initial state of the orga-

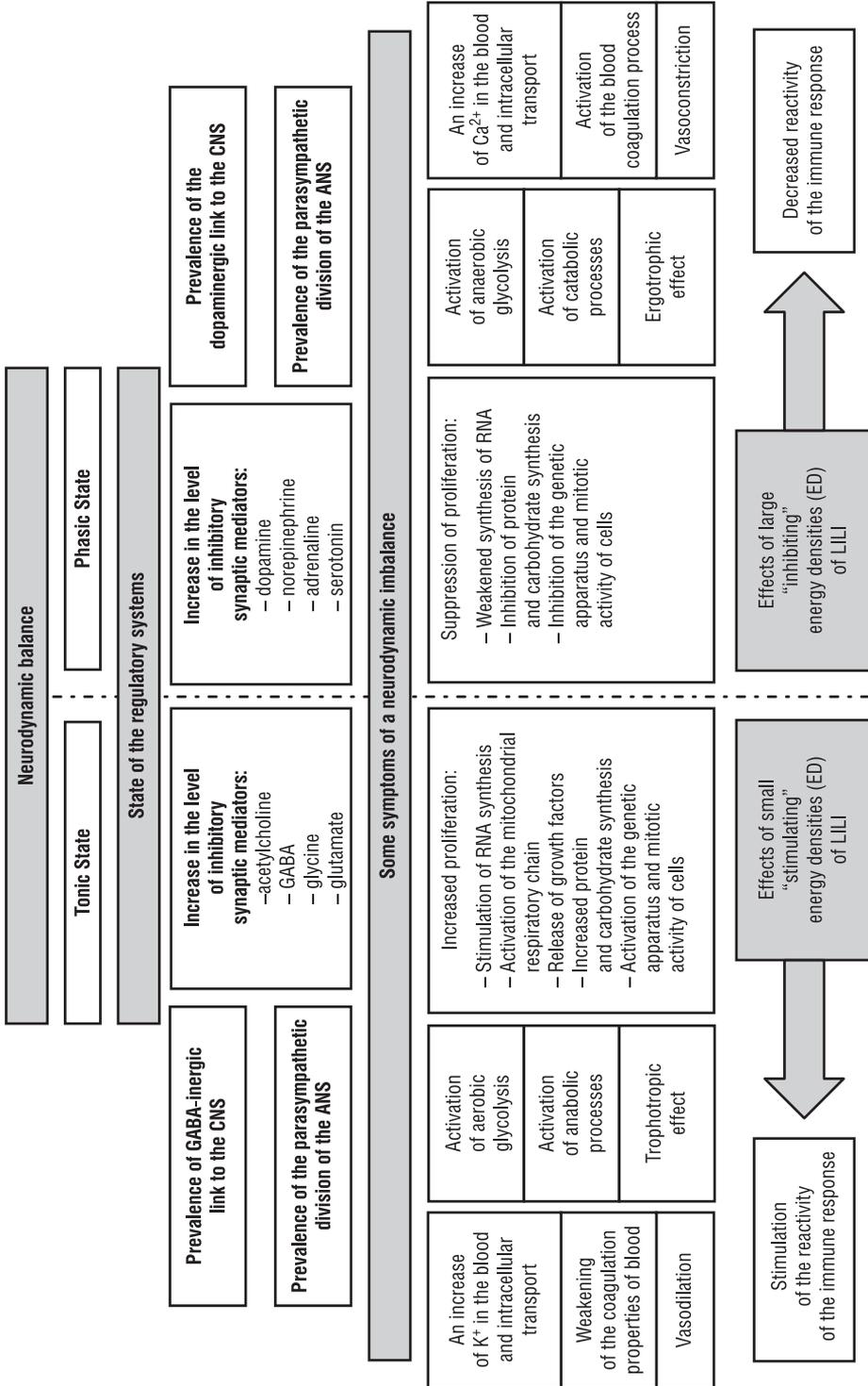


Fig. 3. Schematic representation of the concept of neurodynamic regulation of homeostasis by low-intensity laser light

nism and for the etiopathogenetic justification of laser therapy (LT) methods based on the proposed concept of the neurodynamic model of the pathogenesis of the diseases.

Normally, there are constant transitions from the phasic state to the tonic state and back again. Stress switches on the phasic (adrenergic) regulatory mechanisms, which is described in detail by G. Selye (1960) as a general adaptation syndrome. In this case, in response to the prevalence of dopaminergic effects, tonic (GABA-ergic and cholinergic) regulatory mechanisms are triggered. The latter circumstance remained outside the scope of G. Selye's research, and is, in fact, the most important moment explaining the principle of the self-regulatory role of NDG. Normally, two mutually reacting systems restore the disturbed balance.

It seems that many diseases are associated with the prevalence of one of the states of this regulatory system. With a prolonged, uncompensated influence of the stress factor, the NDG model fails to function and its pathological fixation in one of the states: in the phasic, which happens more often, or in the tonic phase, as if passing to the regime of constant readiness to respond to irritation, affecting practically all regulatory physiological processes, especially the metabolic processes. Thus, stress, or constant nervous tension can disturb homeostasis and cement it pathologically, either in the phasic or tonic state, which causes the development of appropriate diseases, the treatment of which should primarily be aimed at correcting the neurodynamic homeostasis. The combination of several circumstances – hereditary predisposition, a certain constitutional type, various exogenous and endogenous factors, etc. – causes the development of a particular pathology in a particular individual – but the true cause of the disease is the general, stable prevalence of one of the states of NDG.

Once again, we draw attention to the most important fact that the CNS and the ANS not only regulate various processes at all levels, but, conversely, a locally acting external factor, for example, laser light, can lead to systemic shifts, eliminating the true cause of the disease – the imbalance of the NDG. Local illumination eliminates the generalized form of the disease. This must be taken into account when developing laser therapy techniques.

Now, it becomes clear the possibility of multidirectional influence depends on the energy and spectral parameters of the laser light – the stimulation of physiological processes or their inhibition. The universality of bioeffects is due, among other things, to the fact that, depending on the LILI ED, both proliferation and the wound processes could be stimulated and suppressed [Kryuk A.S., et al., 1986; Al-Watban F.A.N., Zhang X.Y., 1995; Friedmann H., et al., 1991; Friedmann H., Lubart R., 1992].

Often in methodics, minimal parameters of ED are used most commonly (1–3J/cm² for a continuous mode of operation of a laser with a wavelength of 635nm). However, in clinical practice the conditionally **non**-stimulating effect of LILI is sometimes required. For example, with psoriasis, the proliferation of keratinocytes has repeatedly increased, this disease is typical of a tonic state, in which proliferative processes are activated. It is clear that in this case, the minimum ED of LILI which stimulates proliferation, is inappropriate. It is necessary to apply extremely high power to small areas of the illumination zone in order to suppress excess cell division. These conclusions drawn on the basis of this model were brilliantly confirmed in practice when developing

effective methods of treatment for patients with psoriasis [Pat. 2562316 RU], atopic dermatitis [Pat. 2562317 RU], vitiligo [Adasheva O.V., Moskvin S.V., 2003; Moskvin S.V., 2003], and Peyronie's disease [Ivanchenko L.P. et al, 2003].

Now that we have a fairly complete picture of LILI's mechanisms of action, it is easy to get an answer to some well-known questions.

For example, how does one explain the biphasic nature of the BA of LILI? With absorbed energy increasing, the temperature gradient also increases, which causes the release of a larger number of calcium ions. However, as soon as their concentration in the cytosol begins to exceed the physiologically permissible maximum level, the mechanisms of the return of Ca^{2+} into the calcium depots are switched on, and the effect disappears.

Why is the effect higher in the pulsed mode at an average power of 100–1000 times less than in the continuous mode of illumination? Because the time of thermodynamic relaxation of macromolecules (10^{-12} seconds) is much shorter than the duration of the light pulse (10^{-7} seconds) and very short, pulse in watt power exerts a much greater influence on the state of the local thermodynamic equilibrium than continuous illumination in Milliwatts. This we have come to understand through various studies.

Is the use of laser sources with two different wavelengths effective? Yes, of course! Different wavelengths cause the release of Ca^{2+} from various intracellular depots, providing potentially higher ion concentrations, hence a higher effect. However, it is important to understand that simultaneously illuminating one zone with laser light of different wavelengths is **NOT allowed**, the action should be spaced out in either time or space.

With other methods of increasing the effectiveness of laser therapy, known and developed by our facility on the basis of the proposed concept of the BA of LILI mechanisms, it is possible to become acquainted with them in the second volume of the series of books "Effective Laser Therapy" [Moskvin S.V., 2014].

Therefore, the application of systematic analysis allowed us to develop a universal, unified theory of the mechanisms of the bio-modulating action of low-intensity laser light. As the primary acting factor, local thermodynamic shifts appear that cause a chain of changes in Ca^{2+} -dependent physiological reactions, both at the cellular level and the organism as a whole. Even more so, the direction of these reactions can be different, which is determined by the energy density, wavelength of laser light and the localization of the effect, as well as the initial state of the organism itself (the biological system).

The concept developed by us makes it possible not only to practically explain all the scientific facts already available, but also to draw conclusions to predict the results of the influence of LLLI on physiological processes, and on possible ways to improve the effectiveness of laser therapy.

ORGANIZATIONAL AND LEGAL ASPECTS AND LASER THERAPY EQUIPMENT

General conditions for ensuring laser safety are based on many years of fundamental research [Experimental justification ..., 1988; Sliney D.H., Wolbarsht M.L., 1980]. All current standards are also based on this research, the requirements of which should be kept to as close as possible. The purpose of this chapter is not to retell information from primary sources (although their availability sometimes leaves much to be desired), but emphasis on the especially important points concerning the safe and effective use of medical laser equipment.

It's hard to believe, but recently laser devices have been divided into "helium-neon" and "semiconductor" (except that these "classifications" are completely incorrect). Not 20 years ago, a treatment room contained a single device with one wavelength and one mode of operation, plus a pair of simple nozzles. Modern equipment, even in its simplest form, must satisfy numerous and contradictory requirements, since a variety of methods and fields of application presuppose the presence of a multifunctional doctor's tool for achieving the greatest effectiveness of treatment.

Maximum versatility and efficiency of the equipment allow the physician to provide the following technical capabilities:

- have laser emitting heads operating in several spectral ranges;
- to work in continuous, modulated and pulsed modes;
- have the possibility of external modulation of laser light (BIO-mode, multi-frequency, etc.);
- have the availability of a different specialised attachments and nozzles for laser acupuncture, ILBI, cavity procedures, etc.;
- to ensure the optimal spatial distribution of laser energy;
- have reliable, constant and separate monitoring of all parameters of laser exposure (technique) [Moskvin S.V., 2003⁽¹⁾, 2014, 2016].

The block principle of building laser therapeutic equipment allows the implementation of all of the above.

For the first time in the world, the Matrix Research Centre developed pulsed red (635nm) laser diodes, which are now used in various fields of medicine, but have shown the greatest effectiveness in the method of non-invasive laser blood illumination of (NLBI). This company is the only one that produces these types of laser diodes. They also mastered the production of laser emitting attachments with a wavelength of 525nm, illumination with a power of up to 50mW, specifically for laser-vacuum massage and other medical methods in cosmetology and dermatology. The expediency of using such lasers when exposed to the skin (in particular when combined with a vacuum massage) is due to the fact that at the wavelengths of 525nm and 635nm, there is a maximum absorption of haemoglobin, i.e., the illumination is almost completely absorbed and distributed in only the upper layers of the dermis. Alternatively – which is typical for the impulse regime – it is absorbed at the depth of occurrence of large blood vessels.

As a result, there is not only an immediate and very powerful effect on the vascular system, epidermis and other dermo-epidermal structures, but also in various skin receptors and glands. In addition, there is a pronounced systemic response at the level of the organism as a whole.

Previously, most specialists used laser light as a therapeutic factor, using only the lasers that were available to them, not realizing in full all the unique possibilities of the method. The features of modern laser therapy, both in not only a curative, but also preventive and rehabilitative plan, urgently required the development of new, more effective equipment based on the latest methodological approaches. Many years of joint work of scientists, engineers and doctors allowed the creation of a unique, specialized and modern technical base.

The building block principle of constructing laser therapeutic devices

All these problems successfully allow us to solve the concept of the building block principle of constructing a laser therapy apparatus, proposed by us in the beginning of the 1990's, according to which it is conditionally divided into four compatible parts (Figure 4) [Moskvin S.V., 2003⁽¹⁾].

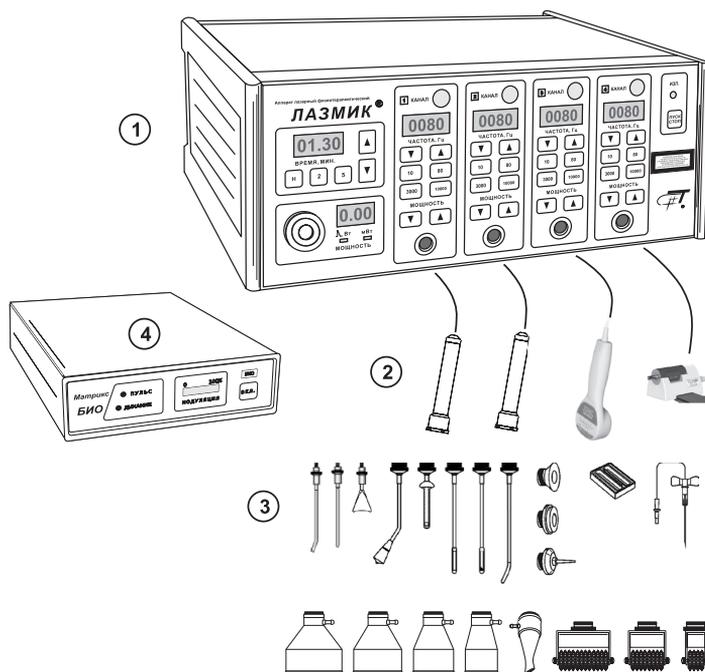


Fig. 4. The block principle of constructing laser therapeutic equipment with the example of the Matrix and Lasmik series: 1 – the base unit (usually a 2 and 4-channel); 2 – laser emitting heads for various LT techniques; 3 – optical and magnetic nozzles; 4 – the biocontrol unit “Matrix-BIO”

The basic unit (BU) – the basis of each set – is a power supply and control unit that performs the following functions: setting illumination modes with mandatory parameter control – frequency, session time (exposure), average and pulsed illumination power.

Parameter monitoring not only insures against errors in the choice of initial values, but also provides the possibility of varying the exposure modes in a wide range, which in turn allows specialists to improve the methodology and seek optimal treatment options.

Various laser emitting heads are connected to the BU with the appropriate attachments required for the implementation of the chosen technique. In modern devices, it is necessary to provide an external modulation of the illumination power of the laser heads, for example, with the patient's own biorhythms, or a multifrequency mode.

The basic building block principle of construction are currently best implemented with the modern Matrix and Lasmik series, which not only are efficient, successfully combined with other physiotherapy devices, but also have a modern design that allows them to work very well in the best medical centres. In addition, on this basis and within the framework of the general concept, specialized high-efficiency laser therapy complexes are created, such as “Urologists”, “Dentists”, “Cosmetologists”, etc.

Reliable information on LILI parameters is extremely important for the validity and reproducibility of LT methods, which provide the most qualitative and effective treatment. It is also necessary to address the safety of the patient and the doctor, to ensure mandatory monitoring of the following parameters:

- wavelength of laser illumination (guaranteed by the manufacturer, indicated in the documentation and special marking on the emitting attachments);
- The illumination power (average and pulsed, for the corresponding types of lasers) is measured with a photometer built into the apparatus;
- the procedure time (exposure), is set and controlled on the base unit;
- frequency (modulation – for continuous lasers operating in modulated mode, or repetition of pulses – for pulsed lasers), is set and controlled on the base unit.

Any important parameter of any technique, such as the area of illumination, is provided by technical means, the design of laser emitting attachments and nozzles.

In this aspect, the most important thing is the determination of the “head-attachment” pair for the most effective implementation of the selected laser therapy technique. For example, it is perfectly understandable that only laser illumination heads like KL-ILBI are suitable for ILBI, but for the non-invasive laser illumination of blood, not only the ML-635-40 (the most effective), but also others (from the top down are located in order of recommendation from best to worst):

- Matrix with IR (904nm) pulsed lasers, ML-904-80 (it is recommended to use TMA
- with one red (635nm) pulsed laser, LO-635-5 or LOK2 (necessary with mirror nozzle attachment ZN-35 or ZN-50);
- with one IR (904nm) pulsed laser, LO-904-15 which is more powerful (necessary with mirror nozzle attachment ZN-35 or ZN-50);
- continuous red lasers such as KLO-635-50 (NLBI) – the least effective.

Continuous IR (700–900nm) lasers are definitely not suitable for NLBI. In general, when exposed to the projection of internal organs, including vessels or joints, it is necessary to use ONLY pulsed lasers!

For laser acupuncture, the laser illumination head KLO-635-5 (635nm wavelength, continuous or modulated mode, 5mW power) with acupuncture nozzle A-3 is used, but it is possible to take a more powerful attachment KLO-635-15, then it is necessary to reduce power at the nozzle outlet with mandatory control with the built-in photometer.

One, two or more laser heads can be connected to the single base unit (BU). Base units can be in one, two or four channel versions in the LASMIK® series, and there is also a version with one vacuum channel. The appearance of a 4-channel BU is due to the fact that in the arsenal of a specialist there must be at least 3–4 emitting attachments, each of which is designed to realize its method of action.

Depending on the availability of either variants, you can mechanically connect the required heads to the connector – for the 2-channel unit, or select the desired channel by pressing the corresponding button, as in the 4-channel version of the BU, while the heads remain permanently connected to the device. In previous generations of laser therapeutic equipment, the process of selecting the desired laser attachment was associated with significant difficulties, the reliability of the connector was seriously reduced from all the constant attachment changes. The devices in the LASMIK® series do not have this kind of drawback, they have an extremely convenient and ultra-reliable connector, which makes the portable and light 2-channel units very popular.

A 1-channel version of the BU in professional medicine is usually not used, (an exception is for intravenous laser blood illumination) since there is an obligatory “one patient – one vein – one laser attachment” rule in this case. However, now, even for the ILBI technique, 2-channel base units (Lasmik-ILBI) are already produced, which is caused by the rapid spreading of the combined ILBI-635 + LUVBI technique, and the presence of two or more laser emitting attachments in the ILBI package, which is practically normal now.

Two independent BU channels are needed for techniques that require simultaneous exposure of two laser emitting attachments to two zones (paravertebrally, to the projection of blood vessels and lymph nodes, to joints on both sides, etc.). In addition, simultaneous, rather than consistent coverage of different areas significantly reduces the time of the procedure.

Surprisingly, however, we often encounter some “experts” who suggest that the with presence of two channels, we can allow the procedure to be performed on two patients at the same time! This is outright stupidity, which will not be commented on further. In recent years, medical centres can often be found to have one base unit with 5–7 or more illuminating attachments. This is often justified for the effective implementation of laser therapy techniques, but not for mass therapy!

The devices of the Matrix series have also been recently upgraded and now use special TRS 6.35mm stereo connectors, manufactured using the unique 3-wire LASMIK® technology, which are not only exceptionally convenient, but also extremely reliable. Thus, the main difference between the LASMIK® series devices is the maximum possible frequency value of 10.000Hz, whereas in all laser therapeutic devices of

the previous generation, the maximum frequency for pulsed lasers did not exceed 3000–5000Hz.

All modern devices provide a light indication when it is switched on, a sound and light indication at the beginning and end of the session. The change in the illumination power, pulse repetition frequency and the time of the procedures is carried out on the BU electronically, by pressing the corresponding buttons. When the maximum or minimum value is reached, a distinctive audio signal is heard.

This organization of management and the design of the panel (keyboard), respectively, were the most successful, and are implemented in most *modern professional* devices. There are many devices which are too simple and that have only a few modes, “fixed” frequencies and a timer. These devices do not allow many laser therapy techniques to be implemented. Either they are “too sophisticated”, for example, with a graphics panel, which is not only extremely difficult to control, but with the same result there is a lack of choice for optimal modes.

Unfortunately, we can still see that even very primitive devices with only a few frequencies and timer options are still encountered, and power measurement is carried out in percentages, even though it is necessary to be done in W or mW. Even more, these lasers are “stuck” with a garland of completely unnecessary LED’s.

The Lasmik device is convenient, extremely simple and at the same time versatile, because with the one-touch button you can set the exposure time (most often 2 or 5 minutes) or the frequency (usually 80, 3000, 10 or 10.000Hz – in this sequence). Such parameters are used in 98% of the techniques, i.e., it is possible to save time when preparing for the procedure and to ensure no error, but if necessary, it is also easy to choose another exposure or frequency, all within a very wide range.

The main precautions when working with therapeutic laser systems

The devices of the *Matrix* and *Lasmik* series are designed for the impact on the patient with LILI, in the following special conditions prepared by personnel authorized to work with lasers.

The operating conditions of laser devices should exclude the impact on the patient and medical personnel due to the specular and diffusely reflected illumination (except for therapeutic purposes). The START/STOP button (illumination activation) must only be pressed AFTER the laser emitting attachment is installed at the site of action or the photodetector of the apparatus (for power measurement).

For electrical safety, the devices belong to class II, type B (household electrical appliances) and do not need any special organizational coordination or measures to be taken, other than the usual safety instruction.

It is forbidden:

- to begin work with the device, without having familiarized oneself attentively with the instruction of operation;
- to shine laser illumination on foreign objects, especially shiny items capable of causing reflection of the laser;
- look directly into the laser beam or shine laser directly into the eyes;

- work for persons who are not directly involved in servicing the device;
- leave the machine switched on while unattended.

Personnel are prohibited from:

- observing direct or mirror-reflected laser illumination during operation of lasers of the 2nd-4th class without means of individual protection;
- placing the laser beam on objects that cause its mirror reflection, if this is not related to the production need; Laser illumination with a wavelength of 380 to 1400nm poses a great danger for the retina of the eye, and illumination with a wavelength of 180 to 380nm and more than 1400nm – for the anterior eyes.

I would like to once again pay attention to the absolute harmlessness of LILI, if we talk about laser therapeutic devices with classes of laser dangers 1 and 2, which are not only safe, but also the most effective.

A completely different thing – Class 3 and 4 laser danger devices, which should be used extremely cautiously, since their illumination can not only damage the eyes, but also the skin. The use of such devices for laser therapy is not only meaningless from the point of view of the lack of the need for the presence of powerful (high-energy) illumination to implement effective treatment methods, but also undesirable because of the danger that may harm the health of patients and mistakes made when working with them. It is necessary to remember the difficulties in organizing their operation (the need for a separate room, the availability of special protective screens, hoods, etc.).

It is always necessary to remember: incorrect application of the method, inaccurate and inattentive handling of laser devices can lead to negative consequences, manifested in the absence of a therapeutic effect (that is, discrediting the method) or initiating an unplanned response of the organism.

Classification of laser medical equipment, its features and terminology

The energy parameters of the laser source and the illumination power, first of all, determines the level of its danger. In Russia, a conditional classification of medical lasers is adopted according to the directions of their application with the designation of the power range:

- diagnostics (10^{-4} – 10^{-3} W, or 0.1–1mW);
- laser therapy, low-intensity laser illumination, LILI (10^{-3} – 10^{-1} W, or 1–100mW);
- photodynamic therapy, PDT (10^{-1} –3W);
- Laser surgery (1–100W).

We will not look at the first version of lasers, they are absolutely safe practically under any conditions.

Lasers used in therapy can be dangerous only for the eyes, however these are very rare cases. If this occurs, it may be due to:

- the power being insignificant;
- the contact techniques (with a mirror nozzle) or cavity, i.e., all illumination is absorbed without reflecting from the surface;
- looking at the area of exposure, especially to shine in the eyes. There is no need for this;

- there needs to be a mandatory presence of protective glasses at the workplace for devices of class 2–4 of laser danger.

The main problem in laser therapy is the provision of guaranteed correct and conscious use of techniques, since with incorrect selection and/or assignment, a response from the body directly opposite to the expected response can be caused. The development of the methodology of laser therapy is based on the fundamental understanding of the mechanisms of action of LILI, the creation of a training system (specialization) and the publication of relevant educational literature, as well as other systematic work in that direction, which almost completely eliminates the possibility of incorrect application of the method.

One important note on terminology. In Russia, laser therapy is the use of LILI with a capacity of 1–100mW, as part of physiotherapy. Recently, laser therapy (LILI) appears internationally under the name *Low-Level Laser Therapy (LLLT)*. In Europe, the US and some other countries, laser therapy is called a surgical (in our understanding) manipulation of surgical lasers with a power that sometimes reaches tens of watts (face polishing, removal of tumours, tattoos, etc.) [Kaneko S., 2012; Matsumoto Y., Akita Y., 2012]. This terminology has been picked up, and if you look at magazines and programs of recent conferences, you will see that all laser manipulation is called therapy there, such as in a recently published translation of instruction on laser cosmetology [Goldberg, D.D. et al., 2010].

This approach is completely unacceptable, at least from the point of view that only doctors with surgical specializations can perform such procedures. Even the word “therapy” itself is misleading about safe work with laser equipment. The word therapy implies “non-destructive methods”. This is why the term *laser physiotherapy* needs to be used in publications in cosmetology magazines [Moskvin S., Ryazanova E., 2011].

Normative documents and a new classification of lasers

In the past few years, many new regulatory documents have begun to operate in the field of laser safety, in particular, IEC 60601-2-22-2008 and IEC 60825-1-2013. The latest standards regulate parameters (wavelength, illumination power, permissible exposure), as well as methods for their control. This makes it possible to classify lasers, presenting appropriate requirements for their design and marking to ensure the safe operation with laser equipment.

IEC 60825-1-2013 established the following ranking of laser equipment in seven classes (in order of increasing the level of danger): 1, 1M, 2, 2M, 3R, 3B and 4 (Table 2).

Protective glasses for laser illumination

The first experiences of using lasers have already shown that the main danger is the illumination of these light sources into the organs of vision. Depending on the power and wavelength, as well as the exposure time (the ratio of these parameters is important), different variants of eye damage are possible [Clark A.M., 1976].

Table 2

Classes of laser hazards in different regulatory documents

Class of Danger (Laser)	Areas of Medicine	Definition of the class of Laser Hazard
1, 1M	Diagnostics, laser therapy	Completely safe lasers, i.e., single exposure to collimated* illumination do not pose a hazard when exposed to eyes and skin
2, 2M	Laser Therapy	Lasers whose collimated illumination is dangerous when exposed to the eyes and skin, and diffused reflected illumination is safe for both the skin and the eyes (according to GOST IEC 60825-1-2013 this is a safe visible range of laser illumination)
3R, 3B	Laser therapy (power up to 500mW), Photodynamic Therapy (PDT))	Lasers, the illumination of which poses a danger in the immediate illumination of the eyes not only by collimated but also diffusely reflected illumination at a distance of 10cm from the surface and/or by collimated illumination
4	PDT, laser surgery	Lasers who's diffusely reflected illumination poses a danger tto the eyes and skin

Key: * – Parallel non-divergent ray of light.

Refer to Appendix 1 for a gradient of points according to the degree of protection, as stated by GOST R 12.4.254-2010.

To select safety glasses, adhere to the following criteria [Smalley P.J., 2011]:

- the indication of the wavelength in nanometres for which they are intended, and the degree of protection (the attenuation coefficient of the laser illumination);
- the presence of side shields;
- adequate transmission of visible light (should be as transparent as possible);
- resistance to shock, have an absence of scratches, chips, cracks and no front reflecting surface;
- The glasses should be comfortable, adjusted to the wearer.

For laser therapy, in most cases, there is enough protection for the L1, and sometimes L2 (according to GOST R 12.4.254-2010), with, for example, the universal glasses ZN-22 “Matrix”, intended for use with physiotherapeutic laser devices operating in the spectral range from 365 to 905nm.

When working with surgical lasers, it is necessary to use glasses for protection against laser illumination (for both the operator and patient) intended only for the wavelength of the laser source used, while the degree of protection should not be lower than the protection class L4 (attenuation of 10.000 times and more). Manufacturers of equipment are required to supply safety goggles with all laser devices.

For therapeutic laser devices, there is enough protection from glasses in the class L1. For devices with a laser hazard class of 1M, they are not formally required at all, but practice shows that in the case of direct observation of the reflected laser beam, the operator becomes quite fatigued. It is, first of all, a laser-vacuum massage. But contact external techniques, NLBI, especially intracavitary, do not provide an observation opportunity in the place of illumination, and laser light does not come out from the tissues, so they are absolutely safe.

BASIC METHODS OF LASER THERAPY

The effectiveness of laser therapy depends both on the choice of methods of exposure and/or their combination, and on the degree of compliance with the basic principles of application of these methods. Even with the most advanced laser therapy device in hand, it is only possible to achieve the best results of treatment by knowing and applying all the parameters of laser therapy techniques in an optimal ratio, performing the required manipulations competently and using a wide range of correlated and combined methods.

The basic principles of increasing the efficiency of laser illumination therapy have already been considered repeatedly [Moskvin S.V., Builin V.A., 1999; 2000; Moskvin S.V., 2003⁽²⁾]. We continue to develop this most important topic in our works, including in this chapter, which we consider to be crucial to the correct understanding and the most critical perception of the entire material of the book. In one of the volumes of the series, “Effective Laser Therapy,” the issue of improving the effectiveness of treatment is the main theme [Moskvin S.V., 2014].

In this chapter, only the *main methods*, most commonly used and more universal, are listed, and some, sufficiently specific, used in a narrow field of clinical medicine, are considered in *Special techniques* (another book written about laser therapy, Moskvin S.V.).

Different methods of laser therapy perfectly complement each other, as they provide not only the inclusion of several mechanisms of regulation and the maintenance of homeostasis, but also carry it out in various ways. The latter is especially necessary in the case when there is a misunderstanding of the specific “physiological” (if it is possible to say so) localization of the arising disturbances, it is impossible to isolate a separate regulatory link, the failure of which led to the development of pathology. In other words, when the etiology and pathogenesis of the disease is unknown, but all the signs of physiological disturbances are present, specialists, using different methods of illumination therapy and guided by the principles of synergy, can adjust the work of most of the already known links of self-regulation in a non-specific manner. The process of such correction automatically restores the functionality and the affected area. Of course, we can talk about this only if the patient’s condition improves clinically or they go into recovery.

The main goal and task of using laser therapy is to select and provide the optimal spatio-temporal parameters of each of the methods of laser treatment, taking into account their specific features:

- wavelength and mode of operation of the laser;
- average or pulsed power of illumination;
- frequency for pulsed or modulated mode;
- localization and area of impact;
- exposure to the zone and the total time of the procedure;
- number and frequency of procedures.

There are rules in a clinical plan, especially in relation to the principles of implementation of methodical schemes. For example, taking into account the condition and age of the patient, the stage of the disease, the presence of additional pathologies,

Based on the knowledge of the physiological mechanisms of LILI, the use of LT in combination with fairly strict adherence to certain basic principles is the basis for the most effective treatment!

All methods have their own characteristics (therefore, some knowledge of the technique for their implementation is required) and differentiate mainly in the localization of the impact:

- external;
- intracavitary;
- intravenous;
- correlated and combined.

The basis of another classification is the nature of the initiated response of the organism, systemic or local (despite the known fact of generalization of the effect at any local effect).

Systemic:

- laser acupuncture;
- laser blood screening, performed either by intravenous access (NLBI), or non-invasively, on the projection of large blood vessels (ILBI).

Local:

- all external and cavitory techniques, the purpose of which is to influence a particular pathological focus or organ.

It is most effective when performing procedures to use at least one systemic and one local mode of action.

External Methods of laser therapy

External methods of laser therapy are distinguished by exceptional diversity, providing the following types of impact:

1. Methods of external, local effects:
 - contact;
 - contact-mirror;
 - distance
2. Reflecting:
 - at the acupuncture points (AP) – corporeal and auricular (laser acupuncture);
 - on the Zakharyan-Geda zones (dermatomes);
 - paravertebrally.
3. On the projection of internal organs, including the transcranial technique.
4. On the projection of blood or lymphatic vessels.
5. On the projection of immunocompetent organs.

The most effective implementation of all these techniques is allowed by most of the modern devices with a variety of laser emitting heads, whose light energy is delivered

to the impact site by means of special attachments/nozzles. This ensures the optimum ED (if the optimum exposure is also set). In addition, *the choice of the zone and the area of illumination, that is, the localization of the impact, is extremely important.* The zone is a place of direct illumination, and the area is an organ that is exposed, possibly in several zones.

Let us consider in more detail the features of the main techniques, which differ in spectral, space-time and energy characteristics.

Local Impact

If the pathological process is localized in the surface layers of the skin or the mucous membrane (damage to various aetiologies, inflammatory processes, etc.), then the effect of LILI is projected directly at it. In this case, the doctor is given the widest opportunities in choosing the parameters of the method. Practically any wavelength of laser light can be used and/or a combination of several spectral ranges; the use of pulsed or continuous lasers, as well as various types of illumination modulation; Application of matrix radiators; combination of LLLT with pharmaceutical drugs of general or local action (laser phoresis) or a permanent magnetic field (magnetolaser therapy), etc.

The distinguishing differences between *contact* and *contact-mirror* are the exposure techniques, when the emitting attachment is in contact with the illuminated surface, as well as a distant (non-contact) technique, in which there is a space between the illuminating attachment and the illuminated surface (Figure 5). This differentiation, however, makes sense only if the laser diode is positioned correctly – outside the head. Only in this case it is possible to reproducibly monitor the area and localization of the impact.

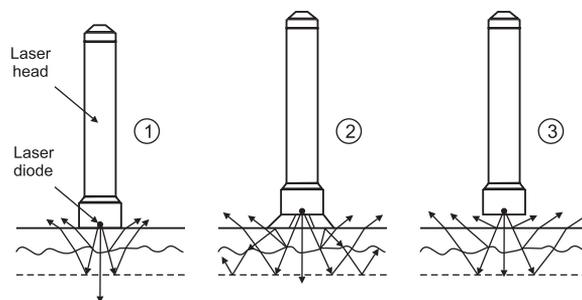


Fig. 5. Contact (1), contact-mirror (2) and distant (3) low level laser therapy techniques

The contact technique is fundamentally different from the contact-mirror effect in that the exposure area in the first variant is minimal (i.e., in this case, the ED is *maximal!*), And in the second case it is *assumed to equal* 1cm^2 , when the power density (PD) and ED are normalized. It is possible to include MLT to the contact-mirror method, for which the most commonly used mirror magnetic attachments are 25mT (ZM-25) or 50mT (ZM-50) for laser emitting attachments with one laser diode, and MM-50 for matrix illuminating attachments.

What you can get with a mirror nozzle:

- the depth and intensity of the therapeutic effect increases;
- the entire energy of the laser light is used, which is not scattered useless in space, but enters the skin and is absorbed there;
- the stability and reproducibility of the procedure is ensured;
- the personnel and patients are protected from reflected light;
- it is easier to guarantee the hygiene of the procedure, since the nozzles are easily removed and disinfected;
- the optimum energy density is ensured, since the distribution of the light energy is automatically normalized to 1 cm^2 .

With a matrix laser illuminating attachments of the ML-904-80 or ML-635-40 type, the reflection occurs from a metal illuminator providing heat removal, therefore only a TMA is used.

Using the contact technique with light pressure, by a mirror or a mirror-magnetic attachment ensures better penetration of laser illumination into the tissue. G.A. Askar'yán (1982), while investigating the passage of LILI through soft tissues and the physical and biological environments, discovered a sharp increase in the penetration of light when the medium was compressed. It turned out that the local pressure on the biotissue caused a stronger transparency than in the case of compression of a layer of turbid physical medium. Y.K. Tolmachev et al. (1994) explains that the mechanism of the increase of tissue transparency by pressing the finely uneven surface of the skin, which leads to a decrease in the reflecting surface, as well as a decrease in skin thickness, not only due to pressure, but also due to stretching due to its elastic properties. In most therapeutic methods of LT, a small compression of soft tissues is recommended, if possible, as an important methodological element that increases the therapeutic effectiveness of laser exposure to the body.

With the contact-mirror technique, the energy of laser light is distributed not only over the surface from the outside, but due to the additional reflection of illumination from the mirror surface, over a much larger volume of the body as well. Both contact techniques are preferable to the distant one, since they make it possible to ensure the stability and reproducibility of the procedure. If, as we have already noted, with a contact-mirror technique, there is a valuation of 1 cm^2 , then it is problematic to talk about the area of impact as such in the contact technique. As a result, the illumination is scattered and distributed over a sufficiently large volume of tissue, while there is no correlation between the area and the number of cells exposed to the illumination.

The remote technique is used when, for some reason, contact with the skin is impossible (open wounds, ulcers, etc.). In this case, based on an understanding of the mechanisms of the biological effect of LILI, it is recommended to use only a stable technique. The main task of the action is to initiate waves of increased concentration of Ca^{2+} , for which the optimum energy density is locally provided, and the mechanism of ion propagation is already triggered independently. With a labile (scanning) technique, no optimal energy parameters are provided at any point of the application, which reduces the effectiveness of laser illumination therapy.

The spectral and energy parameters of the contact-mirror and remote techniques are determined depending on the application area, goals and objectives of the therapy. They can vary within fairly wide limits (Table 3). The contact technique in this sense is more limited, generally everything comes down to one rule: maximal (as high as permitted) power and frequency, but the exposure per zone is strictly limited to five minutes (Table 4).

Table 3

Parameters of the contact-mirror method of LT

Parameter	Value	Usage notes
Laser wavelength, nm (spectrum)	445 (blue), 525 (green), 635 (red), 780, 808, 904 (infrared)	Emitting attachment with one laser
Laser operating mode	Continuous	445, 525, 635, 780, 808nm
	Pulsed	635 and 904nm
Duration of light pulse, ns	100–150	For the pulsed mode
Illumination power	10–40mW	Continuous Mode
	5–25W	Pulsed Mode
Power density (more absorption – less value)	5–40mW/cm ²	Continuous Mode
	5–15W/cm ²	Pulsed Mode
Frequency Hz	80–150	For the pulsed mode
Exposure per zone, minutes	2 or 5	–
Number of affected areas	1–4	–
Localization	On the affected area	–
Methodology	Contact Mirror	With the use of a mirror and magnetic nozzle
Number of procedures per course	5–12	Every day or every other day

The maximum power and frequency for the pulsed mode are limited by safety considerations, since the maximum ED is reached with minimum areas, therefore, these values should not be exceeded in order to avoid a burn. This restriction is present due to certain differences between the cells of the body, which significantly differ in the absorption coefficients for different wavelengths. The less the cells (or the biotissue) absorb, the more power can be used for the contact technique. Localization is specified in each specific case. The methodology, if we talk about research, can vary depending on the model of the experiment.

Optimal exposures of 1.5–2 minutes and 5 minutes are typical for several types of techniques, which have been determined empirically and tested by long-term clinical practice. What is this caused by? In Fig. 1 (see above) there is a graph of the time evolution of the concentration of Ca²⁺ in one local zone of a living cell (human fibroblast) after illuminating it for 15 seconds with a laser with a wavelength of 647nm [Alexandratou E. et al., 2002]. Attention is drawn to the fact that the concentration maxima is observed exactly at these time intervals – 100 and 300 seconds (~ 1.5 and five minutes). If the effect is synchronized with the periods of increasing Ca²⁺ concentration (the most important physiological rhythm of the living cell), then the release of a limiting amount

Table 4

Parameters of the contact method of LT

Parameter	Value	Usage notes
Laser wavelength, nm (spectrum)	780, 808, 904 (Infrared)	Emitting attachment with one laser
Laser operating mode	Continuous	780 and 808nm
	Pulsed	904nm
Duration of light pulse, ns	100–150	For the pulsed mode
Illumination power	100–200mW	780 and 808nm
	80–100W	904nm
Power density (more absorption – less value)	–	The highest possible (maximum)
Frequency Hz	3000–10.000	For the pulsed mode
Exposure per zone, minutes	5	In a number of techniques, up to 30 minutes
Number of affected areas	1–4	More often symmetrical
Localization	On the affected area	–
Methodology	Contact	Directly with a laser diode
Number of procedures per course	15–20	Every day as a rule of thumb. The course is repeated after one month

of calcium ions from the depot is initiated, respectively, and a maximum result can be obtained from Ca^{2+} -dependent processes.

These conclusions are confirmed by direct observations. V.F. Rassokhin and U.B. Lushchik (2005), studied the hemodynamics of blood vessels after exposure to infrared pulsed LILI by computer capillaroscopy, with the same power density in the time range from one to 15 minutes. They proved that it is precisely two and five-minute illumination times that are optimal for the stimulation of microcirculation.

Earlier, we suggested that it is the sufficiently stable periodicity of the propagation of Ca^{2+} waves that causes the endogenous rhythm of biological processes with near-minute and longer periods. Then we explain the mechanism linking exogenous regulators of biological activity (primarily sunlight) with endogenous rhythm drivers (which are unknown). Although the problem of the connection between external and endogenous rhythms is far from being solved, most researchers believe that internal biological rhythms are set by metabolic cycles and are fairly stable, with minimal dependence on external factors [Aghajanyan N.A., et al., 1989]. Correction of internal rhythms, quite possibly, is carried out by waves of calcium ions arising under the action of external disturbances, since metabolic processes are primarily Ca^{2+} -dependent. In the second volume of the series *Effective Laser Therapy*, there is much more material on this subject in chapter four [Moskvin S.V., 2014].

With a distant stable effect, the parameters are completely identical to the contact-mirror technique (Table 3, the distance from the illuminating attachment to the surface is 1.5–3cm, in a more precise control, however, it is not necessary). However, other energy characteristics of the impact are possible. For example, L.I. Gerasimova (2000) developed an effective method for treating patients with a large area of thermal burns,

according to which, the effect is carried out from 4 to 8 seconds per local zone of 2cm², four points per area of damage to 1% of the body surface (a conventional palm size).

Laser Acupuncture

Laser bioactivation of acupuncture points (AP), or laser acupuncture, has become widespread in the treatment of patients with a wide range of diseases, both independently and in combination with other methods. In the method, a very small amount of light energy of strictly localized structures participating in the nonspecific integral response of the organism is used.

It is proved that acupuncture points are highly sensitive to various external influences, in particular, to electromagnetic fields. The effectiveness of the use of physical factors (vacuum, electric current, ultrasound, cold, heat, magnetic field, laser illumination) for the treatment of diverse forms of pathology depends on the specific features of the influencing factor and the place of its application, as well as on the energy parameters of the acting physical factor. There is a uniformity in the direction of the reactions with a single and prolonged action of external factors. Initially, the changes occur at the level of neuro-reflex reactions, and then with a sufficient force of influence (in intensity and exposure) other, more inert mechanisms are included. In all cases of application of laser acupuncture, even in the treatment of severe chronic diseases, when neither classical acupuncture nor medication treatment gives the desired effect, clinical and subjective improvement of the patient's condition is observed.

Laser light with therapeutic parameters does not cause the patient to have any subjective sensations in contact with the skin, however, changes in tissues caused by this effect lead to predictable and reproducible results. Philo- and ontogenetically developed relationships of the outer layers of the human body with internal organs cause a wide range of vegetative reactions of the organism to bioactivate AP through the response of the ANS and CNS to the illumination due to numerous unconditional and conditional connections, which has been proved experimentally and clinically [Moskvin S.V., Builin V.A., 2000].

The point of acupuncture is the area of the most active system of interaction projected onto the skin: *the illumination of the body – internal organs*. The electrophysiological characteristics of the AP are quite specific and are associated with a change in the functional state of internal organs and the neural connections of certain parts of the brain. Laser activation of the AP is accompanied by changes in the physiological characteristics of the relevant organs, which normalize their impaired activity. Organon directed, segmental and general reactions of the body can have not only a toning, but also a toning down character.

Features of laser acupuncture techniques:

- small area of influence (diameter 0.5–3mm);
- nonspecific characteristics of activation of receptor structures;
- the ability to cause directed reflex reactions;
- non-invasive effects, aseptic, comfortable;
- possibility of precise dosing of the effect;

- the possibility of applying the method independently for solving practical problems at a certain stage of treatment, and also in combination with various medicinal, dietary and other physiotherapeutic treatments.

The point effect of laser light in the AP zone with minimum energy is due to the space-time summation of stimulation leading to the development of multilevel reflex and neurohumoral reactions of the organism, primarily the normalization of homeostasis. Different departments of the central nervous system take a differentiated part in the reflex response, the process involves the stem-diencephalic system, which is confirmed by the generalized, symmetrical nature of the changes occurring on the electroencephalogram, the thalamus provides selectivity for individual parameters of stimulation (its frequency and intensity). The reaction that occurs with the participation of the thalamus, which disappears slowly, and the reaction involving the reticular formation is characterized by rapid selective adaptation.

The LILI red spectrum (635nm) penetrates deep enough to get into the zone of laser illumination receptors, various cells, nerve trunks and plexus, lymphatic and blood vessels. According to modern concepts, external stimulation of the AP is converted into nervous excitation, perceived by both the ANS and CNS. The general reaction of the body to laser exposure is carried out in two main ways: neurogenic and humoral. Stimulated synthesis of ACTH, glucocorticoids and other hormones, increases the synthesis of prostaglandins E and F, enkephalins and endorphins. Humoral changes depend on the direction of the initial background; In most cases, the blood composition is normalized and microcirculation is activated. The effects accumulate and reach a maximum at the 5–7th procedure [Moskvin S.V., Builin V.A., 2000].

Based on scientific data and our own clinical and experimental studies on the normalization of sympathoparasympathetic regulation, activation of microcirculation, which are an important link in the pathogenesis of many diseases, as well as the normalization of immunity, a set of zones of general acupuncture, which is called the basic prescription, is proposed (Figure 6) [Moskvin S.V., Buylin V.A., 2000].

The zones of acupuncture are given in the order of influence on them:

- on Monday, Wednesday and Friday: GI4 (he gu), E36 (tszu san li) – symmetrically, VC12 (chung wan);
- Tuesday, Thursday and Saturday: MC6 (her guan), RP6 (san yin jiao) – symmetrically, VC12 (chung wan).

On Sunday, laser therapy is not carried out.

A basic prescription is an important component of laser therapy for various diseases. At the beginning of the procedure, they affect the lesions of the skin, mucous membranes or zones of projection of affected organs on the surface of the skin in the appropriate parameters of the procedures, and then laser acupuncture is performed. If necessary, 2–3 AP can be added to the basic prescription, according to the individual indications of the particular patient.

In addition to the rules known to reflexology physicians, it is worthwhile to take into account some general neurophysiological connections (Skupchenko V.V., Milyudin E.S., 1994). For example, the cerebral hemispheres are connected to the hind brain

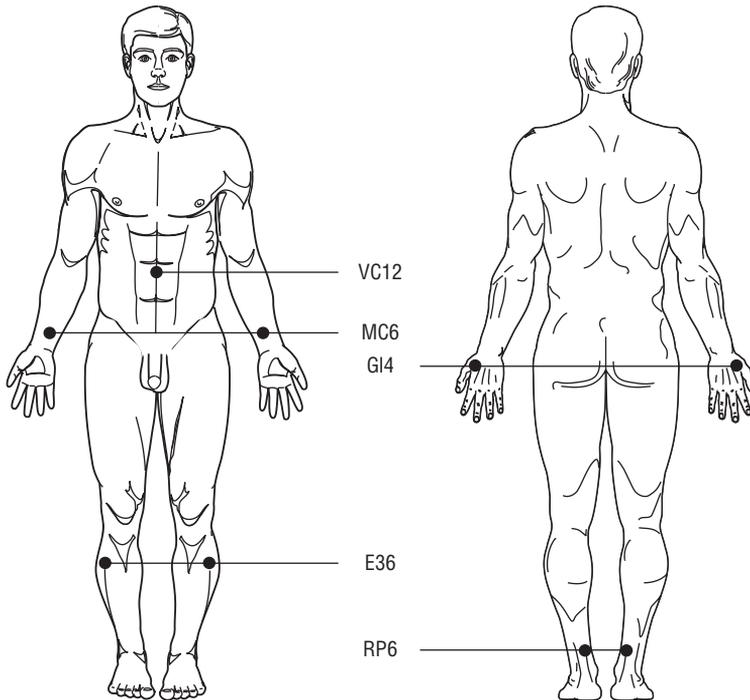


Fig. 6. Basic prescription of laser acupuncture (location of the zones of influence)

according to the mother/son rule, the posterior brain with the dorsal brain according to the “up down” rule and the large hemispheres of the brain with the dorsal brain according to the “noon/midnight” rule. Cross-reciprocal connections correspond to the “noon/midnight” rule, and direct links correspond to the “mother/son” rule. There is a certain dissymmetry in the direction of the relative predominance of Yang influences at the peripheral level, and Yin at the central level. The posterior and anterior median meridians interact with each other according to the rule “up/down”. The left side of the body (Yang) and the right side (Yin) interact with each other according to the rule “husband/wife”. The median meridians (VC and VG) act as the “son”, interacting with the group of channels of the right and left halves of the body according to the “son/mother” rule and synchronizing the phase-shift energy oscillations of these groups at certain time intervals with the realization of phase transitions between them. The use of this data allows the doctor to increase the efficiency of selecting the acupuncture points corresponding to these structures of the central nervous system, especially the auricular points.

The more this or that function is weakly stimulated and more easily oppressed, the more it is activated. The meridian function will be inhibited if the impact on the AP is made during the period of the greatest activity of this meridian (daily, seasonal, long-term). Accordingly, the maximum stimulation of the meridian is achieved by affecting its AP during the period of minimal activity.

Hourly AP:

- 2 hours – F1 (da dun);
- 4 hours – P8 (jing chui);
- 6 hours – G11 (shan yang);
- 8 hours – E36 (tszu san li);
- 10 hours – RP3 (tai bai);
- 12 hours – C8 (shao fu);
- 14 hours – IG5 (yang gu);
- 16 hours – VG6 (chi chung);
- 18 hours – R8 (jiao sin);
- 20 hours – MC8 (Lao Gong);
- 22 hours – TR6 (chi gou);
- 24 hours – VB41 (tsu lin chi).

When treating patients with so-called chronotropic diseases (migraine, malaria, painful menstruation, etc.), laser acupuncture should be started at 2–3 hours (sometimes several days) before the expected appearance of acute symptoms. Treatment for other diseases is effective in calculating the “binom” of the day according to the Chinese calendar (a combination of numbers of “heavenly” and “terrestrial” branches).

In difficult life situations, people with a weakened nervous system begin to malfunction (desynchronization) in the gastrointestinal tract, cardiovascular system, and decrease in sexual function. Thanks to the restructuring of regulatory processes occurring during laser therapy, the nature of the reactions of the adapted organism to aggressive influences changes. All reactions, generally, begin to proceed at a higher rate, including processes of the utilization of oxygen, substrates for energy and proliferative processes, lactic acid and elimination of waste products from the body. The body’s response to the effects of unusual factors and loads becomes more adequate due to the ability to carry out faster and more effective mobilization of various protective mechanisms, characteristic of urgent adaptation adjustment (hyperventilation, cardiac enhancement, blood outlet from the depot, etc.). The effect of laser on the body is not only a stimulation, it is biomodulation, the final effects of which depend on the initial state of all vital processes of the organism. The effect of laser on the body “removes obstacles” for the sanogenetic activity of the ANS-CNS system.

In these techniques, we give the acupuncture points according to the French classification.

The order of exposure: first AP head, then auricle, corporal and distal. The doctor should know the location of the points well and immediately put the acupuncture attachment of the device on the desired area with a small compression of soft tissues perpendicular to the surface of the skin.

The parameters of the acupuncture technique are presented in Table 5. When the corporeal points are exposed to the continuous or modulated red LILI (635nm), the power at the end of the acupuncture nozzle is 2–3mW (without modulation) and 1–1.5mW (with modulation) [Builin V.A., 2002]. When applied to the auricular points, LILI with a wavelength of 525nm (green spectrum) is used, since such illumination is absorbed much stronger, the scattering of light is minimal, and the selectivity of the action is ensured.

Table 5

Parameters of the method of laser acupuncture

Parameter	Value	Usage notes
Laser wavelength, nm (spectrum)	525 (green)	On the auricular AP
	635 (red)	On the corporal AP
Laser operating mode	Continuous or Modulated	–
Frequency Hz	In description	Only for the modulated mode
Illumination* power – mW	0.5–1	525nm
	2–3	635nm
Exposure per single AP, seconds	5–10	On the auricular AP
	20–40	On the corporal AP
Number of affected areas	Up to 15	–
Localization	In description	On the auricular AP
	In description	On the corporal AP
Method	Contact	With the acupuncture nozzle
Number of procedures per course	10–12	Every day

Key * – on the output of the acupuncture nozzle.

To influence the corporeal AP, the laser emitting attachments are intended for the Matrix and Lasmik series – KLO-635-5 (maximum power) or KLO-635-15 (power is reduced and controlled) with an A-3 acupuncture nozzle (fibre diameter 1.3–1.5mm).

Effects on the Zakharyan–Geda zones (dermatomes)

An important diagnostic criterion for a doctor is the increase of tactile and pain sensitivity in limited areas of the skin, which is observed in diseases of internal organs. It is suggested that painful and non-skeletal cutaneous afferent fibres and visceral afferents belonging to a certain segment of the spinal cord converge on the same neurons of the spinothalamic pathway. At the same time, to some extent the information is lost about which internal organs received excitement, and the cerebral cortex “attributes” this stimulation to the irritation of the corresponding regions of the skin. Similar skin pains observed in diseases of internal organs are called reflected pains, and the areas where they arise are the Zakharyan-Geda zones. The boundaries of these zones are usually blurred and correspond to the radicular distribution of skin sensitivity [Enig V., 1996].

The parameters of the impact are identical to the contact-mirror technique (Table 3). The most optimal use of matrix pulsed infrared-emitting attachments, for example, the ML-904-80 for devices of the Matrix and Lasmik series. Wavelength 904nm, power 40–60W, pulse repetition frequency 80–150Hz, exposure 1.5–2 minutes per zone, contact. It is also possible to use a laser emitting attachment with a single pulsed infrared laser (LO-904-20 for the Matrix and Lasmik series), but a contact-mirror technique (with the ZN-35 or ZN-50 mirror attachment) is mandatory. The wavelength is 904nm, the pulse power is 10–15W, the frequency is 80Hz, the exposure is 1.5–2 minutes per zone, with up to 4–6 zones in one session. Variation in power and frequency is not allowed.

Effects on the paravertebral zones

All internal organs have both sympathetic and parasympathetic innervation, whose influence is often antagonistic. Thus, irritation of the sympathetic nerves leads to an increase in the frequency of heart contractions, a decrease in the motor activity of the intestine, relaxation of the gallbladder and bronchi and a reduction in the sphincter of the gastrointestinal tract. Stimulation of parasympathetic nerve fibres (for example, electric stimulation of the vagus nerve) has the opposite effect: the frequency of cardiac contractions and the force of atrial contractions decrease, intestinal motility increases, the gallbladder and bronchi contract, and the sphincters of the gastrointestinal tract relax. In the physiological conditions, the activity of all these organs depends on the prevalence of certain influences [Enig V., 1996].

But often both departments of the autonomic nervous system (ANS) act together. This functional synergy is seen especially well in the example of heart reflexes from baroreceptors, the excitation of which, as a result of the increase in arterial pressure, leads to a decrease in the frequency and strength of heart contractions. This effect is due to both an increase in the activity of parasympathetic cardiac fibres, and a decrease in the activity of sympathetic fibres.

In most organs that have both sympathetic and parasympathetic innervation, under physiological conditions, the regulatory influences of the parasympathetic nerves predominate. These organs include the bladder and some exocrine glands. There are also organs supplied with only sympathetic or only parasympathetic nerves; They include almost all blood vessels, spleen, smooth eye muscles, some exocrine glands and smooth muscles of hair bulbs [Enig V., 1996].

Experimental and clinical studies have confirmed the possibility of a significant increase in the effectiveness of laser therapy with simultaneous action on the pathological focus and paravertebral zone corresponding to it, which makes it possible to strengthen the results of local effects of LILI, causing both a systemic and directed response of the ANS.

The parameters of the impact are identical to the contact-mirror method (Table 3), but using exclusively pulsed infrared LILI, two laser emitting attachments with one laser (LO-904-20 for the Matrix and Lasmik series) with the ZN-35 mirror attachment, symmetrically. Wavelength 904nm, pulse power 10–15W, frequency 80–150Hz, stable, paravertebral, on the projection of sympathetic nodes, exposure one minute per one zone. In some methods, the time of action is allowed to vary with the increase in the number of fields, and sometimes a labile technique is used.

Effects on the projection of internal organs

This is one of the most common methods of laser therapy. Only pulsed LILI is used, best in the infrared (wavelength 890–904nm) spectrum, less often in the red (wavelength 635nm) spectral region, which we proved by theoretical calculations, direct experiments and in numerous clinical trials [Moskvin S.V., 2003; Moskvin S.V. et al., 2002, 2008, 2014].

It has been noted above, that since the relaxation time of macromolecules is much shorter than the duration of the light pulse ($\sim 10^{-7}$ seconds), at powers calculated in milliwatts (mW) and watts (W), a much more pronounced cellular response occurs. We believe that this is the main mechanism that provides the possibility of implementing the method of external illumination on to internal organs.

The data from experimental and clinical studies makes it possible to speak with full confidence about the higher efficiency of the combined (sequential) exposure to infrared and red laser illumination light. Pulsed laser diodes (LD) with a wavelength of 635nm were specially developed for this method, as well as for influencing the projection of vessels [Moskvin S.V., 1997, 2003⁽¹⁾], which are used in the illuminating attachments for the “Matrix” and “Lasmik” series: LO-635-5 (LOK2) and matrix ML-635-40 (the wavelength of 635nm, the impulse power of 40W) [Pat. 2135233 RU].

Our studies have confirmed the effectiveness of the use of red pulsed LD’s in the experiment with the optimization of LILI parameters in autodermoplasty, especially when combined with a laser light exposure of two wavelengths [Zhukov, B.N. et al., 2003]. The most effective therapy was pulsed LILI (red and infrared spectra) in patients with various ENT diseases [Nasedkin A.N., et al., 2001; Nasedkin A.N., Moskvin S.V., 2011], chronic obstructive bronchitis [Moskvin S.V. et al., 2002], cutaneous vasculitis [Moskvin S.V., Kiani A., 2003], cerebral stroke [Kochetkov A.V., Moskvin S.V., 2004], heroin addiction [Nasedkin A. A., Moskvin S.V., 2004], etc. Some results of the studies are also presented in the second book of the series *Effective laser therapy* (Appendix 3) [Moskvin S.V., 2014].

The use of matrix pulsed laser emitting attachments is justified in most cases. A large area of influence with uniformly distributed power density of illumination from several point sources – laser diodes also makes it possible to significantly improve the efficiency of illumination therapy and obtain a more stable effect [Builin V.A., 2000, 2001]. Due to the dispersal of illumination sources on the surface of the body, the light flux affects a larger volume of biological tissues than the point source [Epstein M.I., 1990]. This ensures the higher chance of absorption of energy in the area of the pathological focus, the localization of which is not always accurately known and can be displaced relative to the body surface when the patient’s position changes.

Almost ***exclusively, the matrix pulsed*** laser emitting attachments ML-635-40 (red spectrum) and ML-904-80 (infrared) for the Matrix and Lasmik series are used almost exclusively for the projection of internal organs (Table 6). Laser emitting attachments with one laser are used extremely rarely and always with a mirror nozzle.

Transcranial laser therapy

This is one of the options for illuminating on the projection of internal organs. The peculiarity of the method is that it is not only beneficial to the lesion (ischemia, trauma), but also to the whole organism – all organs and systems through the activation of various parts of the brain. This is due to the fact that the laser light is very scattered, and when using infrared light in the spectral range of 800–904nm, almost the entire brain is exposed to the illumination, and it is not always possible to confidently predict which parts are affected, and how they will react.

The basic characteristics of the methodology are presented in Table 6, in more detail its various options are discussed below in terms of some circumstances that need to be considered when choosing and varying the values of these parameters.

Table 6

Parameters of LT when projected on to internal organs

Parameter	Values	Usage notes
Laser wavelength, nm (spectrum)	635 (red)	–
	904 (infrared)	
Laser operating mode	Pulsed	Matrix emitting attachment, surface area 10 cm ²
Duration of light pulse, ns	100–150	For the pulsed mode
Illumination power, W	35–40	635nm
	60–80	904nm
Power density, W/cm ²	4–5	635nm
	8–10	904nm
Frequency, Hz	80–10.000	Depending on the depth of the proposed impact and wavelength
Exposure per zone, minutes	1.5–2 or 5	–
Number of affected areas	1–4	–
Localization	On the projection of internal organs	–
Methodology	Contact	Through the TMA
Number of procedures per course	5–12	Every day, or every other day

With *in vivo* experiments, different spectral ranges and regimens are used, but their results cannot serve as direct recommendations for clinical use because of the very significant differences in human and animal sizes (specifically the head). There are also fundamental differences in some physiological processes, for example, neuroendocrine regulation of the immune and vascular systems.

However, in clinical conditions, only pulsed matrix lasers with a wavelength of 904nm are used, most often for the treatment of patients with cerebrovascular pathology [Kochetkov A.V. et al., 2012], and in BIO mode for patients with partial optic nerve atrophy [Brezhnev A.Y., 2003], etc.

J.B. Walker et al. (2005) demonstrated changes in epileptiform activity in the hippocampus after illumination with an argon laser (488nm, 25mW, area 5mm) *in vitro*, which indicates the photosensitivity of the CNS and the potential for the regulation of various processes at this level. However, the question must be repeated of whether the delivery of illumination to the right place with such a wavelength and the mode of operation of the laser, if one wishes to realize these possibilities in the clinic.

The transcranial effect of LILI in the near-infrared spectral region (808nm, continuous and modulated modes, 25mW/cm², optimal ED 4.5J/cm²) for several (up to five minutes) increases the ATP content in the cerebral cortex in embolized rabbits [Lapchak P.A., De Taboada L., 2010]. Infrared LILI can modulate the excitability of the motor cortex at the optimal exposure time of five minutes, and the greatest activity

of the brain is observed within 20 minutes after exposure [Konstantinovic L.M. et al., 2013].

An analgesic effect was demonstrated in rats during transcranial illumination with IR LILI (820nm, 1000Hz modulated, optimal ED 12J/cm²), both alone and in combination with naloxone (0.5 and 10 mg/kg), the effect of which is enhanced. This confirms, in the opinion of several authors, the opioid mechanisms of the analgesic effect of laser illumination [Hagiwara S. et al., 2008; Navratil L. Dylevsky I., 1997; Wedlock P.M, Shephard R.A., 1996; Wedlock P. et al., 1996].

Y.-Y. Huang et al. (2012) showed that the illumination with LILI with a wavelength of 660nm and 810nm eliminates the effects of an artificial craniocerebral trauma in rats (neuroprotective action, reduction of inflammation and stimulation of neurogenesis), but the result was absent at wavelengths of 730nm and 980nm. In this case, modulated laser light with 10Hz turned out to be much more efficient than in continuous mode. This is another example of how erroneously the abstract phrase “infrared LILI penetrates deeper”, without specifying the wavelength and purpose of this penetration.

Transcranial laser illumination (wavelength 808nm, continuous mode) improves cerebral blood flow in rats, including through the release of nitric oxide [Uozumi Y. et al., 2010].

In a controlled clinical study, a pronounced positive effect of the transcranial LT technique (1064nm, a lighting area 4cm in diameter, 250mW/cm², in the forehead region, four zones, symmetrically lateral and medial regions, on both sides for one minute per zone, eight minutes only) on the cognitive and emotional functions of a person [Barrett DW, Gonzalez-Lima F., 2013].

J.C. Rojas and F. Gonzalez-Lima (2011) review the transcranial technique separately for restoring brain and vision functions that are impaired due to injuries or illnesses, and in the latter case, LED's with different wavelengths are more often used, which is quite acceptable for illuminating the eyes (Tables 7 and 8).

There are many results from research done by Russian scientists on laser therapy in ophthalmology, including the use of transcranial techniques, as well as many years of practical experience. But even a superficial review of these works will contain several hundred references, so it is not possible to consider this issue in detail within the topic of the chapter and book.

Despite the existence of very significant experimental material demonstrating the effect of LILI continuous lasers, LED light, and even an infrared lamp, in clinical conditions, only pulsed matrix laser illuminating attachments with a wavelength of 904nm should be used to achieve the maximum result using a transcranial technique. This choice is determined, we repeat, not by the wavelength (better penetration), but by the high efficiency of the pulsed mode.

In addition to the use of low-intensity pulsed Infrared laser light in the transcranial technique for its intended purpose (see above), it is also possible to indirectly influence, for example, to increase trophic tissue supply. The transcranial effect of pulsed LILI with additional modulation at a frequency of 10Hz with a carrier of 3000Hz after physical exertion (swimming with a weight at the tail) promotes the activation of DNA synthesis in all studied tissues. But in skeletal muscle and the thymus this effect remains the same as in the group without Physical weight, and in the cerebral cortex

Table 7

The results from the transcranial effect of low-intensity light (coherent and incoherent) on the brain

Light source	Wavelength, nm	Parameters of the method	Effect	Studies (References)
Laser Diode (LD)	808	7.5 mW/cm ² , 0.9 J/cm ² , 2 min per zone	Improvement of neurologic recovery, acceleration of the operation of the subventricular neural network after occlusion of the middle cerebral artery (rat), stroke	De Taboada L. et al., 2006; Oron A. et al., 2006
LD	808	25mW/cm ² , 4.5J/cm ² , 2-5 min, continuous operation	Improvement of motor functions after an artificial embolic stroke (rabbit)	Lapchak P.A. et al., 2004
LD	808	25mW/cm ² , 4.5J/cm ² , 2-5 min, modulated mode, frequency of 1000Hz	An increase in the content of ATP in the cerebral cortex after an artificial embolic stroke (rabbit)	Lapchak P.A. et al., 2007, 2008
LD	808	1J/cm ² per zone	Improvement of the clinical state after ischemic stroke in humans	Lampl Y. et al., 2007
LD	808	10-20mW/cm ² , 1.2-2.4J/cm ² , 2 min per zone	Improvement of motility 5 days after closed traumatic brain injury and reduction in the size of the area of brain damage from 12.1% to 1.4% 28 days after injury (mouse)	Oron A. et al., 2007
LED	633 and 870 (Matrix)	22mW/cm ² , 13.3J/cm ² , 10 min for one procedure	Improvement of cognitive function in patients with chronic light craniocerebral trauma after 2-4 months of treatment	Naeser M.A. et al., 2010
LD	670	40mW/cm ² , 2J/cm ²	Reduction of destruction of dopaminergic cells in <i>substantia nigra</i> after administration of a toxic drug (mouse) imitating Parkinson's disease	Shaw V.E. et al., 2010
Lamp	700-2000 (maximum 1072nm)	6 min per session, 10 days	Improved memory performance for spatial navigation (mouse), imitation of disorders in Alzheimer's disease	Michalikova S. et al., 2008
LD	810	250 mW/cm ² , 60J/cm ²	Reduction of the severity of depression, increased prefrontal blood flow	Schiffer F. et al., 2009

Table 8

The results from the transcranial effect of low-intensity light (coherent and incoherent) on organs of vision

Lightsource	Wavelength, nm	Parameters of the method	Effect	Studies (References)
Helium-Neon Laser (HeNe Laser)	633	10.5mW, beam diameter 1.1mm, daily for 2 weeks for 2 min	Restoration of the structure and function of the damaged optic nerve (rats, rabbits)	Schwartz M. et al., 1987; Assia E. et al., 1989
LED	670	28mW/cm ² , 12 J/cm ² , 3 sessions	Restoration of the structure and function (vision) after systematic intoxication with ethanol (rats)	Eells J.T. et al., 2003
LED	633	2mW/cm ² , 21J/cm ² , 6 sessions	Restoration of the structure and function (vision) after injection into the vitreous body of the rotenone (rat), the rationale for the treatment of hereditary optical neuropathy Leber	Rojas J.C. et al., 2008
LED	670	16J/cm ² , 5 sessions	Restoration of structure and function after laser coagulation of the retina (monkey)	Eells J. et al., 2008
LED	670	50mW/cm ² , 20J/cm ² , 5 sessions	Restoration of vision in P23H-3 rats as a rationale for the treatment of pigment retinitis	Eells J. et al., 2008
LED	670	50mW/cm ² , 360J/m ² , 5 sessions	Restoration of structure and function after damage by light	Qu C. et al., 2010
LD	904	40mW/cm ² , area diameter 10mm, modulated with a frequency of 3MHz	Improved functions in an 86-year-old man with age-related macular degeneration	Rodriguez-Santana E. et al., 2008

it is halved compared to the control. Thus, pulsed infrared LILI can play the role of an active adaptogen, creating a proliferative supply for increasing functional activity, both in the directly illuminated tissue (in the cerebral cortex) and in the peripheral regions (muscle and thymus) [Zubkova S. M., Mikhaylik L.V., 1995].

The impact of pulsed infrared LILI before physical activity allows us to identify differences in the response of the central nervous system and the muscular system. In the skeletal muscle, with subsequent physical exertion, the level of its proliferative supply decreases. A single 10-minute laser illumination of the motor region of the cerebral cortex can stimulate biosynthetic processes in the cells of the central nervous system, in cells of the thymus and skeletal muscles, increasing the functional capacity of these tissues not only in intact animals, but also in animals after active physical activity. Activation of nuclear chromatin of pyramidal and starry neurons of the cerebral cortex of the rat after 10 minutes of its illumination by a continuous LILI of the red region of the spectrum (633nm) was also detected [Krylov O.A., 1989].

Impact on the projection of immunocompetent organs

The method is used for various conditions associated with disorders in the immune system, with the effect being carried out directly on the projection of immunocompetent organs, most often lymph nodes and the thymus. Studies have shown that LILI affects almost everything, both the humoral and cellular components of the immune system, but the direction of the impact may vary depending on many factors. The choice of the method is quite individual for each nosology, but the literature on this topic is quite enough for each specialist in his field to decide on the most optimal treatment regimen.

The most commonly used is the matrix pulse infrared laser illuminating attachment ML-904-80 for the Matrix and Lasmik series. It is allowed to use emitting attachments with a single pulsed infrared laser, but only with the ZN-35 or ZN-50 mirror (contact-mirror technique). Other variants are possible, but in any case it is permissible to use exclusively pulsed infrared LILI (wavelength 904nm). The parameters of the procedure are presented in Table 9.

Table 9

Parameters of LT when exposedon to the projection of immunocompetent organs

Parameter	Values	Usage notes
Laser wavelength, nm (spectrum)	904 (Infrared)	–
Laser operating mode	Pulsed	–
Duration of light pulse, ns	100–150	–
Illumination power, W	60–80	–
Power density, W/cm ²	8–10	–
Frequency, Hz	80–150	–
Exposure per zone, minutes	1.5	Exposure is strictly limited
Number of affected areas	1–2	–
Localization	On the projection of immunocompetent organs	Matrix emitting attachment, surface area of 10cm ² or with one laser
Methodology	Contact or contact-mirror	Through the TMA or mirror attachment
Number of procedures per course	8–10	Daily

Intracavitary methods of laser therapy

The intracavitary methods of laser therapy differ in the localization of access to hollow organs. Procedures are carried out with the help of specialized optical attachments (see the colour insert), through which LILI is delivered to the required area with a given spatial distribution of the energy of the laser light. Both continuous and pulsed LILI of practically all spectral ranges are used. Since the area of exposure is strictly specified by the shape of the optical nozzle, the illumination power of the attachment is set, as a rule, at the maximum level (we recall that the optical nozzles can lose up to 50% or more). Varying of the ED in this case is carried out only by changing the frequency for the pulsed mode.

We also recall that after passing through a light guide longer than 20cm, the specific properties of laser illumination-spatial coherence and polarization are largely lost, and these components of the spatio-temporal organization of the impact largely determine the effectiveness of the treatment. It is unequivocally shown, both experimentally [Inyushin V.M., Chekurov P.R., 1975], and in the course of clinical studies [Anishchenko G.Y. et al., 1991] that the efficacy of LT with direct exposure to LILI (without a light guide) is much higher. Therefore, it is necessary, if possible, to work without the mediation of an optical fibre or to minimize its length. Our investigations have established that the allowable decrease in the degree of polarization occurs at the length of the fibre of no more than 15–20cm, and at a fibre length of more than 1 metre, polarization and spatial coherence are practically absent [Moskvin S.V., 2000].

For intracavitary exposure, the same LILI and exposure parameters are used as for the contact-mirror technique (Table 3), but the power is set at the maximum level for the selected laser emitting attachment.

Intracavitary LT methods are increasingly being replaced by external influences on the projections of the relevant organs. For example, direct illumination of gastric and duodenum ulcers through the light guide is now almost entirely replaced by the use of matrix pulsed infrared laser emitting attachments that work to improve efficiency in the “BIO” modulation mode of [Moskvin S.V., Zakharov P.I., 2013]. The impact in this case is non-invasive – the procedure is comfortable for the patient and is convenient for the medical staff, with a higher efficiency of treatment.

Sometimes intracavitary laser therapy is correlated or combined with other methods of physiotherapy. For example, when using the vibro-magnetolaser attachment VMLG10 for ALT “Matrix-Urologist” (see colour insert), vibration, a permanent magnetic field and LILI is involved. It is in the direction of combining and correlating various physical healing factors that the prospects for the development of intracavitary methods should be considered.

Non-invasive (supra-vascular, non-invasive, transcutaneous, transcutaneous) laser blood illumination

According to some authors, the effects caused by intravenous laser blood illumination (ILBI) and other variants of non-invasive laser blood illumination (NLBI) are

identical [Zubkova S.M., 2009; Koshelev V.N. et al., 1995; Pat. 2440161 RU]. Our many years of practical experience and clinical research directly testify in many cases to the benefit of NLBI as a more effective and simple method, although most practitioners prefer ILBI. The comparison in this case is carried out exclusively between the most optimal variant of the NLBI using the matrix pulsed red lasers (wavelength 635nm) and ILBI-635 (wavelength 635nm, continuous mode, power 1–3mW). When the choice of this or that variant of the technique is determined solely by the capabilities of the available equipment, the comparison cannot be correct because the lighting parameters are often far from optimal.

Nevertheless, each of the methods have their own peculiarities, both in terms of implementation, technology and results. For example, S.M. Zubkova (2012), in addition to the general mechanisms, also considers additional the effects shown through the CNS an activation in the non-invasive variant of blood illumination (Figure 7).

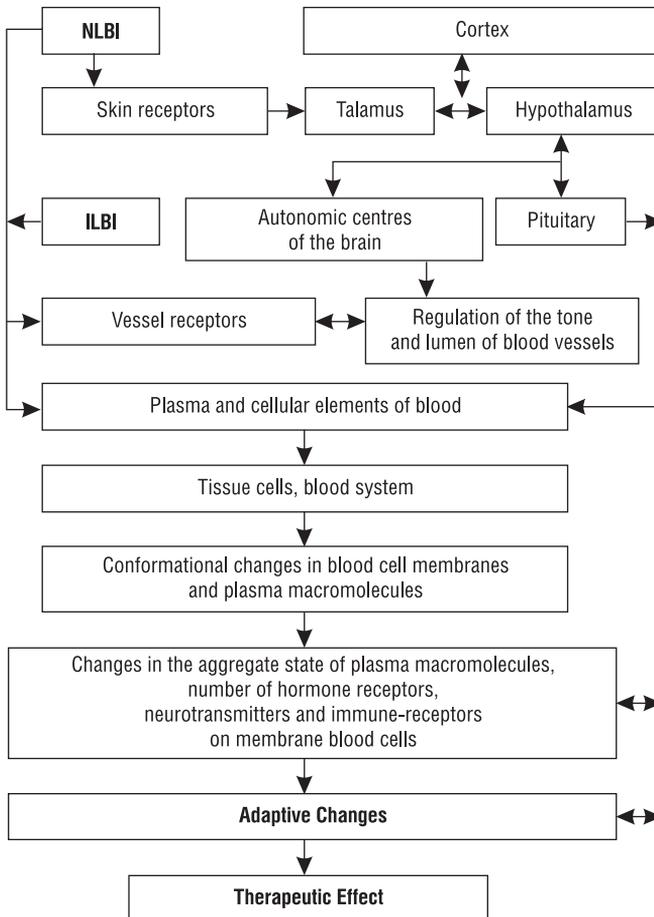


Fig. 7. Physiological reactions of the organism to the NLBI and ILBI (Zubkova S.M., 2012)

Intravenous and external methods of illumination differ in that in the first case, the effect is carried out directly on the blood, and in the non-invasive version, LILI passes through the skin, the walls of the vessels, etc., is absorbed, dissipated. At the same time, the power is lost, spatial coherence and polarization almost completely disappear, but the temporal coherence (monochromaticity) is completely preserved.

We have been engaged in the development of both NLBI and ILBI for more than 20 years, understanding that each of them occupies its own niche, there have always been and always will be supporters of both options for blood illumination. An example in the book *Laser Therapy in Neurology* [Kochetkov A.V., et al., 2012], in which both methods are presented without opposition. The only, perhaps, persistent recommendation is the undesirability of using invasive techniques in paediatrics. Even then, with a reservation regarding the illumination of the blood with infrared spectrum of LILI, since the effectiveness of the ILBI-365 (LUVBI) technique is so clearly high that in some cases it cannot be dispensed with.

Experimental-clinical studies showed high therapeutic efficacy of NLBI, comparable at least with intravenous laser blood illumination in the version of ILBI-635. For example, V.N. Koshelev et al. (1995) conducted a comparative evaluation of the effectiveness of the methods and proved their identity, at least in part as a positive effect on the blood coagulation system and the normalization of oxygen balance in the affected limbs.

NLBI pulsed infrared LILI (890nm) in combination with mexidol in patients with diabetes mellitus with long-term non-healing wounds and ulcers of the lower extremities contributes to the normalization of the parameters of the coagulating and anti-scavenging blood systems, immunity and nonspecific resistance of the organism [Tolstykh P.I. et al., 2000].

M.A. Kochetkov et al. (2000) compared the efficacy of two methods of laser therapy in patients with ring-shaped granuloma:

- local illumination with a laser matrix illuminating attachment ML01K (890nm, pulse power 80W, frequency 80Hz, exposure two minutes per area, per procedure and no more than 10–12 minutes);
- NLBI by a helium-neon laser (HeNe) (633nm, continuous mode) to the area of the elbow vein, projection with an output power of 20–25mW and an exposure of 20–30 minutes; the course of laser therapy consisted of 7–10 daily procedures.

Patients received 1–3 courses of laser monotherapy. It turned out that both methods have comparable efficacy, causing a unidirectional action leading to a significant improvement in the clinical picture of the disease, normalization of microcirculation indices and reactivity of microvessels in the affected skin [Kochetkov M.A. et al., 2000].

In the NLBI method, as an alternative to the intravenous method, the pulsed red LILI with a wavelength of 635nm demonstrates the best efficiency, and somewhat worse results in the infrared spectrum (wavelength 890–904nm). The non-invasiveness and simplicity of the procedure, availability of NLBI in any condition (up to the area) can significantly improve the effectiveness of illumination therapy by adding NLBI to traditional methods of treating a wide range of diseases, including at home. For many years, we have been working on optimizing the NLBI modes, and have shown that not

only the pulsed mode of laser operation is required, but it is the wavelength of 635nm. Matrix lasers are much more efficient than with one laser, even with a mirror nozzle that increases the illumination zone up to an area of 1cm².

NLBI is extremely successfully used for disorders of cerebral circulation at the stage of early rehabilitation of patients with cerebral stroke [Kochetkov A.V., 1998; Gorbunov F.E. et al, 2003]. In the author's techniques, the effect is performed by pulsed infrared LILI on the projection of the common carotid artery (CCA) or vertebral artery (VA) depending on the localization of the lesion: on the projection of both CCA with the prevalence of carotid insufficiency syndrome in patients, and on VA also symmetrically in the syndrome of vertebro-basilar insufficiency.

We also pay special attention to the optimal exposure time, which is 2–5 minutes for NLBI, and not 10–20 minutes, as is the average for ILBI-635, the most common variant of the procedure. This is a significant difference, which must always be remembered.

Unfortunately, confusion in terminology and methodology is also quite common, for example, when the endonasal effect is completely unreasonably given for a non-invasive version of laser blood illumination. Referring to the work of Soviet scientists, who first showed the effectiveness of the ILBI, Chinese “colleagues” proposed this such localization, motivating their choice by the close location to the surface of a sufficiently branched capillary network. At the same time, the parameters of the method that were chosen were completely inadequate – power 3.5–4.5mW (633nm), 30 minutes/day for 30 days – obviously, guided by the parameters of the ILBI [Li Q. et al., 1998]. It is with such technical characteristics and techniques that cheap Chinese crafts are sold all over the world, and they are aimed at women with the promise of solving almost all health problems. This is completely unacceptable, the authors of the idea cannot even imagine the possibly catastrophic consequences from its application, especially without medical supervision. It is necessary for all to unambiguously understand and remember that the illumination of peripheral vessels in any localization, such as “laser clocks” on the wrist [Litscher G., Litscher D., 2016] is useless, but endonasal [Liu T.C.Y. et al., 2010] is extremely dangerous, and it is only a discrediting the method [Moskvin S.V., 2014].

The method of endonasal laser illumination is well known, as well as the fact that it is accompanied by reflex excitation of hypothalamic formations controlling the secretion of biologically active substances participating in various processes: stimulation of uterine contraction, regulation of circulatory and reproductive systems, control of the production of various hormones, etc. [Ramdoyal S., 1990; Serov V.N. et al., 1988], other ways of laser light activation of different sections of the central nervous system are possible (Stoyanov, A.N., 2007). This multifaceted and ramified reaction of the organism urgently requires extremely cautious and maximally controlled influence on this zone.

The endonasal technique in obstetrics and gynaecology is used only by specialists to correct hormonal changes (635nm, 10–15mW, exposure no more than 5 minutes) [Fedorova T.A. et al., 2009]. Endonasal illumination by LILI is used sometimes in ENT-practice, but with other goals and parameters, the output power from a special optical nozzle is not more than 3–5mW with exposure time from 30 seconds to 2 mi-

minutes (depending on the age) [Nasedkin A.N., Moskvina S.V., 2011]. In this case, only local influence is provided, and the probability of a generalized response is minimal.

Recently, a number of authors have already come to an understanding of the inadequacy of the initially proposed parameters of the endonasal technique in the Chinese version. This version uses limited power (3–5mW) at a wavelength of 635–650nm and exposure time of 5 minutes [Liu T.C.Y. et al., 2010], and argues that it supposedly “positively” affects blood coagulability in women with a normal pregnancy [Gao X. et al., 2008]. Why use LILI to illuminate pregnant women without an apparent pathology? This is completely incomprehensible. If you look on the Internet, you’ll see another picture: a lot of sites continue to offer devices that advertise, instruct and recommend to illuminate for 30 minutes every day. Some, if I may say so, “scientists” and “clinicians” drag this Chinese rubbish to the Russian market under the guise of “innovative” technology. An engineer, neurologist, oncologist and two representatives of the Chinese company conducted a fake “study”, according to which they recommend using a “laser clock” for the treatment of patients with arterial hypertension [Leonov B.I., et al., 2016]!

If we return to the question of the influence of LILI on the circulatory system, then the proposal to cover peripheral blood flowing through the capillary network is absolutely pointless. Such an effect is carried out with any external technique, without replacing NLBI, which is carried out only in the projection of large vessels, even if it is continuous LILI with increased power. The method of NLBI in the most optimal variant (pulsed LILI and matrix illuminating attachments) has been well developed, has long been used successfully in Russia, is characterized by a high degree of systemic influence, and complements other methods of laser exposure well.

ILBI is carried out almost exclusively by injection into a cubital vein, sometimes through a permanently installed subclavian catheter. NLBI occurs transcutaneously, most often in the projections of the left supraclavicular zone, carotid arteries, inguinal or popliteal vascular bundles when exposed to one area for 2–5 minutes [Kosmyrin A.G., 2005; Kochetkov A.V. et al., 2012; Leiderman N.E., 2010; Leiderman N.E. et al., 2009, 2010; Moskvina S.V., 2008]. That is, when implementing NLBI, they always affect the projection of large vessels (arteries or veins) in the region close to the lesion focus. This is another difference between the methods – localization of the impact.

So, a non-invasive blood-illuminating option has almost all the benefits, the method is often more efficient, easier and cheaper, less time is spent on the procedure, etc., but for a number of reasons the ILBI develops faster and is much more common in practical public health. We are trying to improve both technologies, we believe that specialists should have a choice, because each of the methods has its advantages.

Methodology of the NLBI. Illumination is carried out through the skin always on the projection of large vessels (arteries or veins) in the region close to the focus lesion (Figure 8), with an exposure of 2–5 minutes [Kosmyrin A.G., 2005; Kochetkov A.V. et al., 2012; Leiderman N.E., 2010; Leiderman N.E. et al., 2009, 2010; Moskvina S.V., 2008]:

- the projection of the common carotid artery (sinocarotid zone) is symmetrical (Figure 8, zone 2);

- projection of the vertebral artery symmetrically (Figure 8, zone 3);
- supraclavicular area on the left (Figure 8, zone 4);
- Vascular bundles in the inguinal region are symmetrical (Figure 8, zone 5);
- popliteal fossa symmetrically (Figure 8, zone 6).

The optimal parameters of the procedure are shown in Table 10:

- NLBI-635, the most effective option, pulsed LILI of the red spectrum (635nm), PD – 4–5W/cm², pulse duration 100–150ns, frequency 80Hz;
- NLBI-904, pulsed infrared LILI (890–904nm), PD – 8–10W/cm², pulse duration 100–150ns, frequency 80Hz.

It is preferable to use the ML-635-40 matrix laser emitting attachment, having 8 Laser Diodes of pulse power of 5W each (635nm wavelength, pulse mode, light pulse duration 100–150ns) arranged in 2 rows, total power 40W (Figure 9).

With less efficiency in the technique, you can use the Infrared-matrix laser emitting attachment ML-904-80 (wavelength 904nm, power 60–80W, frequency 80Hz). It has been proved that matrix illuminating attachments are always the best choice, but in the absence of them, attachments with a single laser, also operating in a pulsed mode with only a mirror nozzle are permissible.

The maximum power for this type of laser attachment is selected (Table 10) and does not vary, and it is also inadmissible to exceed the exposure time of 5 minutes when illuminating one zone [Laser therapy ..., 2015]. The question of a possible

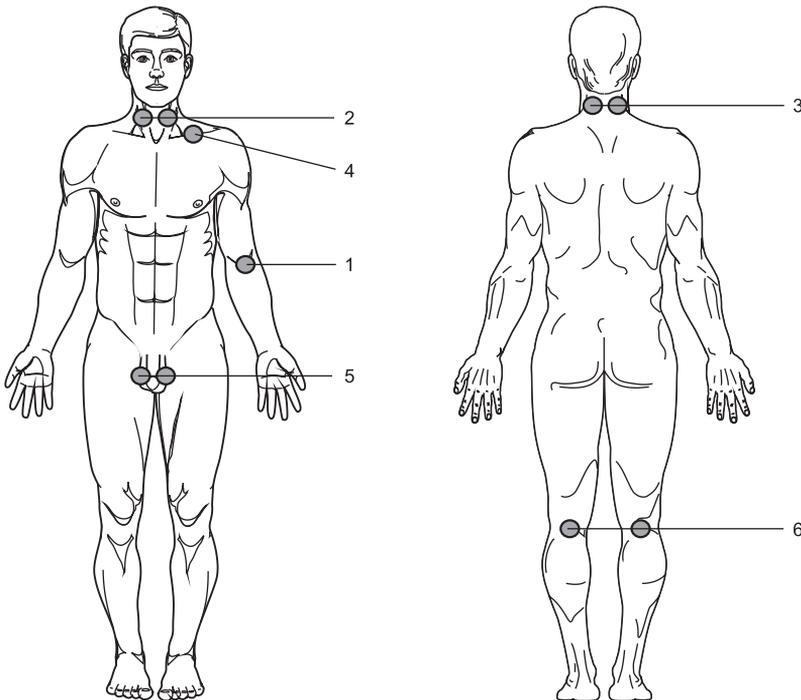


Fig. 8. The basic exposed zones for laser blood illumination

Table 10

Method parameters of NLBI

Parameter	Values	Usage notes
Laser wavelength, nm (spectrum)	635 (red)	NLBI-635
	904 (infrared)	NLBI-904
Laser operating mode	Pulsed	–
Duration of light pulse, ns	100–150	–
Illumination power, W	30–40	Matrix emitting attachment ML-635-40 for ILBI-635
	60–80	Matrix emitting attachment ML-904-80 for ILBI-904
Power density, W/cm ² (surface area 10cm ²)	3–4	NLBI-635
	6–8	NLBI-904
Frequency, Hz	80–150	–
Exposure per zone, min	2–5	–
Number of affected areas	2–4	Symmetrically
Localization	On the projection of large blood vessels close to the lesion focus	Fig. 8, zones 2–6
Methodology	Contact information	Through the TMA
Number of procedures per course	10–12	Daily

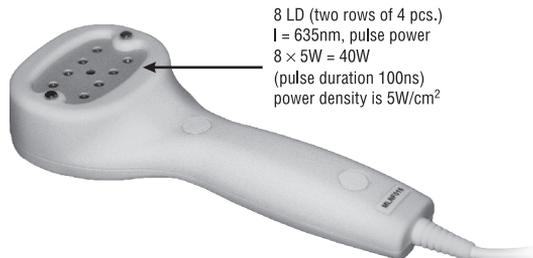


Fig. 9. The matrix laser emitting head ML-635-40 for NLBI, contact and distant techniques, as well as for the projection of the internal organs

increase in the frequency (that is, the average power for pulsed lasers) remains open, additional studies are needed to study the effect of this parameter on the effectiveness of the procedure for various pathological conditions. One thing is certain: frequencies below 80Hz (you can also sometimes encounter frequencies as little as 5Hz) for pulsed lasers are completely ineffective.

Intravenous laser blood illumination (ILBI)

Due to its exceptional universality and effectiveness, the method has found the widest practical application in cardiology, pulmonology, endocrinology, gastroenterology, gynaecology, urology, anaesthesiology, dermatology and other fields of medicine. Deep scientific substantiation of effectiveness and predictability of results also contribute to

the use of ILBI both independently and in combination with other therapeutic methods [Geynits A.V. et al., 2012; Kapustina G.M. et al., 1996].

Numerous publications have reported positive results obtained by intravenous laser blood illumination using a helium-neon laser. The choice of this type of laser and the wavelength of 633nm, respectively, was due exclusively to the availability factor, but not to efficiency. Modern laser therapeutic devices that use laser diodes (Matrix-ILBI, Lasmik and Lasmik-ILBI) not only have better mass and overall parameters, but are also more effective due to the optimization of the wavelength of laser illumination. The development and production of disposable sterile light guides allowed to make this procedure absolutely safe and comfortable for patients.

ILBI can be carried out practically in any hospital or clinic. The advantage of outpatient use is a decrease in the possibility of developing a nosocomial infection, a good psychoemotional background is created, which allows the patient to remain functional for a long time, while undergoing procedures and receiving full treatment [Moskvin S.V., Azizov G.A., 2004].

The successes of the method in cardiology were marked by the presentation of the USSR State Prize in 1989 to B.S. Agovu, M.R. Bohua, G.M. Kapustin, N.N. Kipshidze, I.M. Korochkin, L.A. Marsagishvili, V.S. Sergievsky, N.I. Stepanishevoy and G.E. Chapidze "...for the development and introduction into clinical practice of the method of treatment of various forms of IHD with a helium-neon laser". However, in our opinion, the method is unduly used in practical health care. In addition to the unique therapeutic effectiveness, I would like to draw attention to the economic benefits of its use. In the conditions of limited budget financing, the use of mandatory and voluntary health insurance by the medical and preventive institutions come to a fore. ILBI is recognized by insurance companies, and in most regions of the Russian Federation it is financed through the MHI system.

The versatility of the ILBI is due not only to a positive effect on the blood and all its components, but also to the whole organism by triggering the central mechanisms of regulation and maintenance of homeostasis through the response of the ANS and CNS. Additionally, the adaptation strategy of the organism to the changed conditions of the environment and the state of the organism is corrected.

For ILBI, LILI is used only in a continuous mode (there are still few publications on the study of the modulation capabilities), the effect is carried out intravenously through special disposable sterile light guides with a puncture needle, most often into a cubital vein (Fig. 8, zone 1). [Geynitz A.V., et al., 2012; Kapustina G.M. et al., 1996].

Instructions for the procedure

Checking the efficiency of the equipment and power of the illuminating attachment

1. Connect the laser emitting attachment to the device (base unit) by inserting the connector on the cord of the illuminating attachment into the corresponding connector of one of the channels on the front panel of the device. It is necessary to pay attention to the correspondence of the colour of the strap of the illuminating

attachment to the wavelength of the laser illumination chosen for carrying out the procedure (Table 11).

Table 11

Corresponding strap colour on the laser emitting attachments to the wavelength

Attachment name	Wavelength nm	Spectrum	Average power*, mW, no less than:	Colour of the corresponding strap
KL-ILBI-365-2 (for the UVBI)	365	Ultraviolet	2mW	Purple
KL-ILBI-405-2	405	Ultraviolet	2mW	Purple
KL-ILBI-445-2	445–450	Blue	2mW	Blue
KL-ILBI-450-20	445–450	Blue	20mW	Blue
KL-ILBI-525-2	520–525	Green	2mW	Green
KL-ILBI-525-20	520–525	Green	20mW	Green
KL-ILBI-635-2	635	Red	2mW	Red
KL-ILBI-635-20	635	Red	20mW	Red
KL-ILBI-808-40	808	Infrared	40mW	Orange

* – at the output of a disposable fibre KIVL-01 manufactured by the Research Centre “Matrix” (9444-005-72085060-2008).

2. Insert the **control** light guide (used **only** for measurements) **without a needle and without a cap** in the optical connector of the illuminating attachment. Use a test light guide only or a cannula with a cut-off light guide (optical fibre). **ATTENTION!** Do not measure the output of a sterile light guide and if there is a needle!
3. Close the light guide (cannula) to the power indicator window.
4. Press the START button on the base unit.
5. Set the appropriate illumination power by the corresponding buttons, controlling it by the indicator on the device. For emitting attachments with a power of 2mW, it is always maximum, only the presence of illumination and the correspondence of the parameter are controlled. A check for these attachments is usually carried out once a day before starting work.
6. Turn off the illumination by pressing the START button again.

The sequence of the procedure of ILBI (Figure 10)

1. The patient is lying on their back.
2. Attach the laser emitting attachment to the patient’s forearm with a cuff (or a light guide with a patch).
3. Set the required time for the procedure on the machine.
4. Prepare a vein for an intravenous procedure.
5. Open the packaging, remove the disposable sterile KIVL-01 light guide. **Attention!** Measurement of illumination power by a sterile light guide with a needle is not carried out, only through a special tip (see above).
6. Remove the protective cap from the needle.

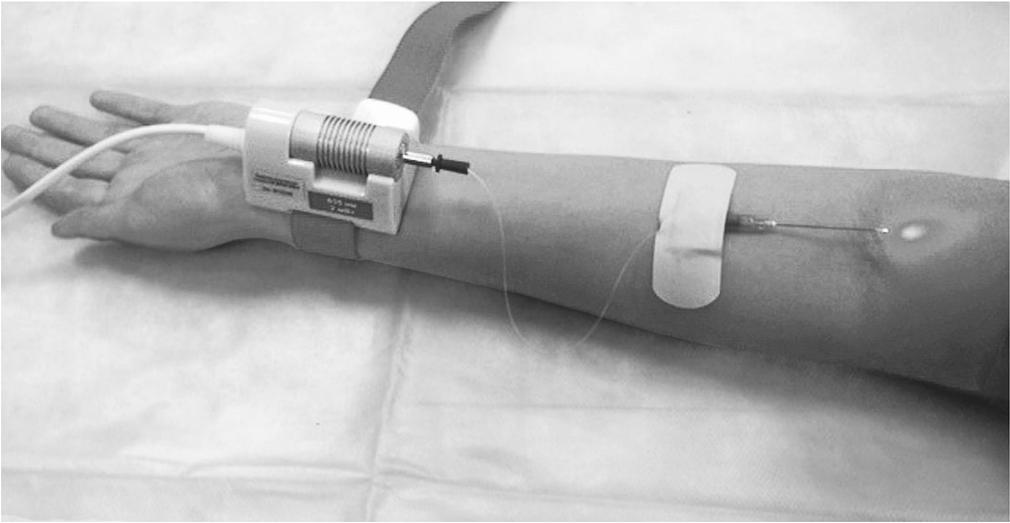


Fig. 10. The ILBI procedure

7. Slide the needle from the “butterfly” by 2–3mm (so that the light guide completely enters the needle). **Attention!** The light guide should protrude from the needle, otherwise the light will not come out of it. But it is not possible to insert a needle with a protruding fibre, it must be “removed” inside the needle before inserting it into the vein!
 8. Make a venipuncture with a needle. After the appearance of blood in the hole (confirmation of the entrance to the vein) insert the needle on the “butterfly” until it stops and fix the “butterfly” on the hand with a plaster.
 9. Remove the harness. The tip of the KIVL-01 light guide (cannula) is inserted into the socket of the illuminating attachment (or the main light guide) to the stop.
 10. Press the START/STOP button on the machine to start the procedure.
 11. At the end of the procedure (the device will automatically turn off), remove the light guide with the KIVL-01 needle from the vein and dispose of it.
 12. Remove the emitting attachment or main light guide from the hands (for outdated models of apparatus). The procedure is finished.
- The parameters of the various methods are presented below.

Basic method of ILBI

In the first version of the method with which it all began, helium-neon lasers with a wavelength of 633nm and a power of 1–5mW were used, but from the beginning of the 20th century they switched to more efficient laser diodes with a wavelength of 635nm and the technique was called ILBI-635. Laser diodes operating in other spectral ranges are used in the most modern apparatuses, which allow implementing new,

more effective in some cases, variants of the technique: LUVBI, ILBI-445, ILBI-525. Table 12 shows the basic techniques, which use the minimum power and exposure.

Table 12

Parameters of the procedure ILBI-635 (“classical”), ILBI-365 (ILBI-405, LUVBI), ILBI-445, ILBI-525

Parameter	Value	Usage notes
Laser wavelength, nm (spectrum)	635 (red)	ILBI-635
	365–405 (ultraviolet, UV)	ILBI-365 (ILBI-405, LUVBI)
	445 (blue)	ILBI-445
	525 (green)	ILBI-525
Laser operating mode	Continuous	–
Illumination power*, mW	1.5–2	At the output of a disposable fibre
Exposure, minutes	10–20	ILBI-635
	2–5	ILBI-365 (ILBI-405, LUVBI)
	3–5	ILBI-445
	5–8	ILBI-525
Localization	Vienna ulnar median (v. Mediana cubiti)	Fig. 8, zone 1
Methodology	Intravenously	Through the disposable sterile fibre KIVL-01 manufactured by the Research Centre “Matrix” (TU 9444-005-72085060-2008)
Number of procedures per course	7–12	Daily or every other day

* – at the output of a disposable fibre KIVL-01 manufactured by the Research Centre “Matrix” (TU 9444-005-72085060-2008).

There are a variety of methods, different from the basic versions of ILBI.

Power (1.5–2mW) does not change, but in some cases it increases to 20–25mW using special laser emitting attachments. There are methods in which power varies from procedure to procedure, and with this it is necessary to be extremely careful, constantly monitor all the regimes, not only power, but also the time of the procedure, which depends significantly on wavelength and power.

Exposure. The “standard” procedure time of 10–20 minutes may increase, sometimes up to 25–30 minutes, but no more than that [Meshalkin E.N., Sergievsky V.S., 1989]! Laser blood illumination with an exposure of up to 45–60 minutes, used in anaesthesiology during operations with general anaesthesia, pursues exclusively protective purposes and is not a medical procedure [Avrutsky M.Y. et al., 1997; A. c. 1762944 SU].

It is also necessary to know the specific features of the use of ILBI in the older age group (reduction of exposure to 7–10 minutes) [Davydenko T.E., 2006]. In paediatrics, the rule applies: smaller age = lower ED, or exposure, if we’re talking about ILBI [Moskvin S.V., et al., 2010], for ILBI-635 this is expressed in decreasing the exposure to 5–7 minutes, although we are convinced that almost always the intravenous method in children can be replaced by external illumination of the left supraclavicular area.

Combined technique, ILBI-635 + LUVBI (basic)

Laser therapeutic devices of the Matrix and LASMIK® series (Matrix, Matrix-ILBI, Matrix-Urologist, Lasmik, Lasmik-ILBI). The laser illuminating attachment KL-ILBI-635-2 (red spectrum, wavelength 635nm, output power of the light guide 1.5–2.0mW), exposure 15–20 minutes, and laser emitting attachment KL-ILBI-365-2 or KL-ILBI-405 for LUVBI (UV spectrum, wavelength 365–405nm, power 1.5–2.0mW), exposure 2–5 minutes (Table 13).

A combination (alternation of regimes) allows to optimize the effect both on the immune system (UV spectrum, 365–405nm) and for the purpose of enhancing the trophic tissue supply (red spectral region, wavelength of 635nm) [Geynits A.V., Moskvina S.V., 2010; Geinits A.V. et al., 2012].

During a course of 10–12 daily procedures, the techniques will alternate. For example, 1st day – LUVBI, in the second procedure – ILBI-635, on the third day LUVBI is repeated and so on. The first procedure may be ILBI-635 if there is a pronounced trophic disorder, and vice versa, the first three procedures are often enough, for example, in case of a deficiency of the immune system, infectious diseases, etc., are carried out by LUVBI. But it is strictly unacceptable to carry out both procedures in one day, or especially at the same time!

Table 13

Method Parameters of ILBI-635 + LUVBI

Parameter	Value	Usage Notes
Laser wavelength, nm (spectrum)	365–405 (UV)	LUVBI
	635 (red)	ILBI-635
Laser operating mode	Continuous	–
Illumination power*, mW	1.5–2	At the output of a disposable fibre
Exposure, minutes	3–5	LUVBI
	10–20	ILBI-635
Localisation	Vienna ulnar median (v. Mediana cubiti)	Fig. 8, zone 1
Method	Intravenously	Through the disposable sterile fibre KIVL-01 manufactured by the Research Centre “Matrix” (9444-005-72085060-2008)
Number of procedures per course	10–12	Every day, alternating every other day, ILBI-635 and LUVBI

* – at the output of a disposable fibre KIVL-01 manufactured by the Research Centre “Matrix” (TU 9444-005-72085060-2008).

Combined technique, ILBI-525 + LUVBI (basic)

Laser therapeutic devices of the Matrix and Lasmik series (Matrix, Matrix-ILBI, Matrix-Urologist, Lasmik, Lasmik-ILBI). The laser illuminating attachment KL-ILBI-525-2 (green spectrum, wavelength 520–525nm, output power of the fibre 1.5–2.0mW, exposure 7–10 minutes) and laser emitting attachment KL-ILBI-365-2 or

KL-ILBI-405-2 for LUVBI (UV spectrum, wavelength 365–405nm, power 1.5–2.0mW, exposure 2–3 minutes).

A course of 10–12 daily procedures with alternate change of techniques. For example, the first day – LUVBI, the second procedure – ILBI-525, the third day is repeated LUVBI and so on [Pat. 2513474 RU, 2562316 RU, 2562317 RU]. The parameters of the basic methodology are presented in Table 14.

We repeat, it is strictly prohibited to carry out both procedures in one day, and especially not at the same time!

Of course, the above basic techniques do not cover the full range of possibilities of the method, to increase the efficiency it is also possible and necessary (within the permissible limits) to change the laser illumination power, wavelength and exposure. If such methods for increasing the efficiency of the ILBI exist, then in ILBI the variation in the parameters is very limited, for example, the exposure is strictly limited to a time range of 2–5 minutes, the power is optimal, the frequency is usually 80–150Hz. Clinical studies using higher capacities and frequencies during the NLBI are still very few [Moskvin S.V., 2016].

Table 14

Method parameters ILBI-525 + LUVBI (basic)

Parameter	Value	Usage Notes
Laser wavelength, nm (spectrum)	365–405 (UV)	LUVBI
	520–525 (green)	ILBI-525
Laser operating mode	Continuous	–
Illumination power*, mW	1.5–2	At the output of a disposable fibre
Exposure, minutes	3–5	LUVBI
	7–8	ILBI-525
Localisation	Vienna ulnar median (v. Mediana cubiti)	Fig. 8, zone 1
Method	Intravenously	Through the disposable sterile fibre KIVL-01 manufactured by the Research Centre “Matrix” (9444-005-72085060-2008)
Number of procedures per course	10–12	Every day, alternating every other day, ILBI-525 and LUVBI

* – at the output of the KIVL-01 disposable light guide manufactured by the Matrix Research Centre (9444-005-72085060-2008).

INDICATIONS AND CONTRAINDICATIONS FOR THE PURPOSE OF LASER THERAPY

The indications are determined by the mechanisms of the biomodulatory action (BA) of LILI and the peculiarities of the clinical application of laser therapy. Long-term research and a wealth of clinical experience allow us to speak with full confidence, not only about the safety of the method, but also the extraordinary breadth of those areas of medicine where it can be used. Universality, which, perhaps, still surprises some, is explained both by the non-specificity of the BA of LILI, and by the common mechanisms of the pathogenesis of most diseases. Laser light is not actually a therapeutic factor, but it causes a reaction of the organism with the necessary strength and in the right direction, which independently eliminates existing disorders, restores the disturbed homeostasis, and as a result, the patient makes a successful recovery.

Contraindications are set out in the official normative document (Clinical recommendations) [Laser therapy ..., 2015], among which the following syndromes are distinguished:

- haemorrhagic;
- neoproliferative;
- Hyperthermia (fever, body temperature of the patient above 38 °C);
- systemic (cardiac, vascular, respiratory, renal and hepatic) and multiple organ failure (general severe condition of the patient);
- cachectic (severe general exhaustion);
- epileptic;
- convulsive;
- Hysterical.

Insufficient understanding of the processes occurring in these situations, and the lack of the necessary number of reliable studies limit the application of the method.

There are relative contraindications, determined by the specific pathogenesis of a particular disease, for example, laser therapy is not prescribed for patients with certain joint diseases in the case of a sharp exacerbation of synovitis with a high degree of activity of the inflammatory process [Laser therapy ..., 2015].

It is also necessary to pay attention to the fact that some contraindications for general clinical practice are by no means the same for narrow specialists working in specialized institutions or divisions. For example, there are enough publications that confirm the safety and effectiveness of laser therapy in the treatment of epilepsy patients, but only neurologists can use this method.

A non-randomized clinical trial (continuous LILI mode, wavelength 635nm, power 4mW, exposure – 1 minute and no more than 10 minutes) in complex therapy in patients with arthromiological lesions in haemophilia [Kushnir M.A., 1991] showed that LT helps to reduce arthralgia and prevent the development of trophic disorders in the joints. There were no cases of any undesirable effects. Nevertheless, in spite of the encouraging results of this study, at the moment LT is not allowed to be used for haemophilia [Laser therapy ..., 2015].

The contraindication with such a known property of LILI that is the ability to significantly improve the rheological properties of blood is explained. But haemophilia is a haemorrhagic disease that occurs due to a genetically determined decrease in the activity of clotting factors. It has nothing to do with the rheology (fluidity) of blood. Even more so, numerous studies conclusively prove the beneficial effect of laser illumination on the process of clotting of blood. We will not develop this topic, we will only say that appropriate, special studies are needed to confirm or disprove the validity of the contraindication specified in the clinical recommendations.

There are also a number of limitations for carrying out laser blood illumination, for example, to patients who receive heparin and other anticoagulants. This limitation (not a contraindication!) is associated with activation of microcirculation and improvement of the rheological properties of blood as a result of such exposure. On the other hand, with artificial blood circulation in patients with congenital heart defects, ILBI-405 improves the resistance of the erythrocyte membrane to mechanical action of the pump, reduces haemolysis, allows a longer duration of perfusion with a significant (2-fold) decrease in doses of heparin [Erstekis A.G. et al., 2010].

For the safe use of laser therapy, it is necessary to use competent, pedantic and responsible methods. At the same time, we still have not gotten rid of the legacy of anyone who invented a long list of “contraindications” for laser therapy. For many years, it has been copied from manual to manual, from book to book, that they are allegedly established by the “Rules for working with laser light physiotherapy devices (approved by the USSR Ministry of Health, 1970), taking into account a number of features of illumination from a helium-neon laser” [Instructions for use ..., 1983]. No one has ever seen this “normative document”, no studies have been published, or even a theoretical substantiation of such “recommendations” with explanations of “a number of features of laser illumination.” Interestingly, for more powerful, therefore, potentially more dangerous lasers, there are no such contraindications.

Let’s look at several examples of why these “contraindications” are just a fantasy of unknown authors, given that there are a lot of scientific papers published on this issue as a substantiation of existing limitations for laser therapy in reality [Moskvin S.V., Khadartsev A.A., 2016]. Most often, laser therapy should be prescribed jointly by a physiotherapist and a specialist who knows the pathogenesis of the disease and treats a certain category of patients, for example, children or an older age group.

It is known that practically in all fields of modern medicine, laser therapy is included in the standards of medical care, and paediatrics is not an exception [Order of the Ministry of Healthcare and Social Development of the Russian Federation No. 366n of 16.04.2012]. There are no age limits for laser therapy, but it is necessary to know certain features of the method for children, where a well-known rule applies: “smaller age = lower ED”, or exposure, when talking about ILBI [Moskvin S.V., et al., 2010]. A similar restriction (a decrease in the power, or exposure, for ILBI, by a factor of 2) is also valid for older age groups [Davydenko T.E., 2006; Lutai A.V. et al., 2001; Povorinskaya O.A., 2009].

Sometimes, contraindications include the *active form of tuberculosis*. At the same time, B.M. Maliev and M.B. Shesterina (2001) convincingly, with a thorough ana-

lysis of scientific sources and based on their own experimental and clinical studies, demonstrated that laser therapy can and should be used in the complex treatment of patients with pulmonary tuberculosis, and it is in the active phase, i.e., for specialists this is one of the methods of treatment without any restrictions. Until recently, laser therapy was part of the standard of treatment [Order of the Ministry of Healthcare and Social Development of the Russian Federation No. 1224n dated 29.12.2010], but at present this highly effective method is included only in the standard for equipping a sanatorium for tuberculosis patients of all forms [Order of the Ministry of Health of the Russian Federation No. 932n of 15.11. 2012, Appendix No. 25]. According to this document, there must be at least four pulsed infrared laser therapeutic devices in the sanatorium, but, unfortunately, nothing is said about ILBI-635 and ILBI-365 (LUVBI), as well as other methods of illumination therapy, whose effectiveness in treating patients with tuberculosis is proved by a set of independent studies [Dobin V.L., et al., 2001; Kucher V.A., Mikhei L.V., 1990; Rusakova L.I., et al., 2001; Sutyagina D.A., 2015, Sutyagina D.A. et al., 2010]. Long-term clinical experience of LT application in physiology demonstrated the highest economic efficiency [Prytyko D.A., 2013; Prityko A.G., Prityko D.A., 2013].

It is quite obvious, although it sounds paradoxical at first glance, that it was the high effectiveness of laser therapy that served as the main reason for excluding the method from all recommendations. For example, approved by the Order of the Ministry of Health of the Russian Federation No. 951 of 29.12.2014, there is not a single word about the lasers, only about chemotherapy and the alleged reduction in the timing of its conduct (according to the norms from 2 to 12 months). But the data of long-term studies proving that laser therapy allows the shortening of treatment time and the amount of operative intervention has a significant decrease in the likelihood of recurrence is completely ignored [Bagirov M.A., 1993; Bondarev G.B., 1996; Rusakova L.I., et al., 2001; Topolnitsky V.G., 1992]. At the same time, the clinical experience of Russian scientists is actively being introduced abroad in practical health care, primarily in the treatment of antibiotic-resistant patients [Bajpai A., et al., 2010; Puri M.M., et al., 1995; Singh H.M.P., et al., 1997].

The presence of malignant and benign neoplasms most often causes fear among the ignorant, but this is *not a contraindication for laser therapy* simply because it is part of the standard of medical care for this category of patients as a method of rehabilitation [Clinical recommendations. Oncology, 2008; Order of the Ministry of Health of the Russian Federation No. 1705n dated 29.12.2012].

Almost always such phobias are associative, many of them, having heard the phrase “laser therapy stimulates ...” out of context, comparing the phrase to a tumour that can also be “stimulated”. Myths of this kind are devoted to our recent special publication, the full text of which can be found in Appendix 3 [Moskvin S.V., Khadartsev A.A., 2016].

The appearance of cancer cells in a healthy body occurs constantly, this is the norm. Does this mean that prescribing laser therapy is forbidden? No! Back in the 1960–1970’s, it was unequivocally proved: laser light does not have any mutagenic or oncogenic effects, it does not stimulate the development of cancer tumours, but rather

suppresses them, which is confirmed by thousands of relevant studies conducted in dozens of countries worldwide [Zyryanov B., et al., 1998; Moskvin S.V., Khadartsev A.A., 2016]. Physiotherapy in general is the basis for the rehabilitation of cancer patients [Grushina T.I., 2006]. The Moscow Cancer Research Institute named P.A. Herzen, on July 23, 2009 in Roszdravnadzor, Russia, unveiled new medical technology. FS No. 2009/200 “Low-intensity laser therapy in the rehabilitation of cancer patients” was registered.

According to oncologists, this contraindication concerns only the local effects of LILI on problem areas and with extremely high ED, suppressing the immune system, and the effect on other areas (for example, ILBI) is permissible and more than justified [Zyryanov B.N., et al., 1998]. We deliberately do not touch upon the topic of “large” and “small” ED as it is considered in other specific studies, but it is enough to say that in “laser therapy”, the “pathogenic” regimes are not applied. Moreover, in accordance with the Order of the Ministry of Health and Social Development of the Russian Federation of December 3, 2009 No. 944n “Upon Approving the Procedure for Providing Medical Aid to the Population in Oncological Diseases”, surgical and therapeutic (for PDT – photodynamic therapy) lasers are standard equipment for medical institutions involved in providing medical treatment for cancer patients, i.e., in specialist centres, oncologists are allowed to use much more powerful, hence potentially more dangerous lasers, than those used for laser therapy.

Pregnancy in all terms is also not a contraindication for laser therapy, since it is part of the standard of medical care for this category of patients [Order of the Ministry of Health of the Russian Federation No. 572n of 01.11.2012], and all methods of illumination therapy, including the ILBI, are allowed. Moreover, the intensive care ward, as well as intensive care provided for pregnant women and puerperas should be equipped with laser therapeutic devices [Order of the Ministry of Health and Social Development of the Russian Federation No. 197 of 27.03.2006].

For specialists, the use of laser therapy for various pathological conditions of pregnant women is a common practice [Serov V.N., et al., 1988, 2007; Fedorova T.A., et al., 2009]. In this aspect, it is interesting to compare the archival statistical data of the obstetrical service of the Lviv Oblast for the last 10 years (it was conducted in connection with the fact that a large enterprise for the production of lasers was opened in the region at that time), which showed that there were no tendencies to increase the incidence of congenital anomalies in the womb during this period. There were no children were identified who suffered. The data of studies of menstrual cycles, genital function and gynaecological morbidity in 140 women engaged in the industrial production of lasers in the city of Lviv (Ukraine), that is, subjected to daily, constant and uncontrolled effects of laser illumination, are given. The following anamnestic data was obtained [Lopushan I.V., 1981; Timoshenko L.V., et al., 1985]:

- no harmful effects on menstrual function, normalization of a previously disturbed menstrual cycle;
- Birth and postpartum periods in pregnant women were normal, no adverse effects were noted;

- the overall level of gynaecological morbidity with loss of ability to work on laser production does not differ from that in the enterprise as a whole;
- significantly higher rates of pregnancy in women working directly on laser production.

There are no normative documents regulating the contraindications for laser therapy, in addition to the official clinical recommendations cited above [Laser therapy ..., 2015], and the only condition of work is a sufficiently high level of professionalism of the personnel of the medical institution.

For example, laser therapy is part of the standard of medical care in cosmetology [Order of the Ministry of Health and Social Development of the Russian Federation No. 381n of 18.04.2012], since there are no methods that can lead to undesirable consequences, but there is a list of relative (contingent) “contraindications”, which are suggested as “warnings”. For reference: there are limitations in the variation of the parameters of LILI, and under certain conditions, unpredictable for the *non*-specialist responses of the organism, they are possible [Geynits A.V., Moskvin S.V., 2010, 2012].

In addition, in case a patient has any doubt about the safety of the method, it is necessary to abandon the procedure. Long-term observations of Professor A.V. Kochetkova in the neurological departments of the Russian State Medical Centre “RNC MRK” of the Ministry of Health of the Russian Federation and the Central Clinical Hospital of the RF FMBA, showed that after a placebo effect that simulates the laser therapy procedure, on average, 15% of patients with cerebrovascular diseases experience weakness and dizziness as blood pressure decreases. It turns out that the very word “laser”, directly associates with the word “danger” with a significant portion of the population. This can cause problems. Of course, this is an extreme example, it must be understood by the professional in order to convince patients that *low-intensity laser light is completely safe*, if you follow fairly simple rules. But in the presence of the unchangeable phobia in the patient, it is necessary to abandon the procedure.

Absolute, obvious and undeniable, but at the same time and unofficial contraindication is the unprofessionalism of the person who uses laser therapy, whether it's a doctor or a medical professional. We are talking about the use of correct terminology, strict definition of all parameters of the methodology and ensuring they're error-free during the procedure.

Quite often we hear “arguments” like: “we read this in the book”, “they wrote this on the Internet”, “a professor said to us”, etc. It is necessary to be guided by the current normative base and common sense, and not the opinion of “authoritative” experts, and certainly not the “professionals” on the Internet. Upon the request of “laser therapy” all search engines helpfully show on the first line the corresponding section of the famous pseudo-encyclopedia, where for the most part, laser therapies are written with blatant stupidity. We are not allowed to post reliable information, because it is an American service of outspoken propaganda, and their goal is to hide the objective truth and replace it with blatant lies [Moskvin S.V., 2016].

The problem is, the majority of “contraindications” do not exist, but mistakes, unfortunately, are very tenacious, and despite all the above, specialists, not to mention ordinary people, with regard to laser therapy, have some kind of prejudice. For example,

E.B. Kilardzhieva and A.A. Gaidarova (2016) state that “at present, the advantages of using lasers in dentistry are proven by practice” and note the obvious advantages of LT:

- 1) safe usage;
- 2) the possibility of precise regulation of exposure parameters and dosage accuracy during procedures;
- 3) shown to be highly effective with a fairly broad list of diseases;
- 4) is well combined with other methods of treatment and increases their effectiveness;
- 5) easy to use;
- 6) is preferable in the treatment of infectious diseases, since a large dosage of antibiotics and hormones can be reduced at times.

And suddenly, they completely turn around and unreasonably discover non-existent cons:

- 1) high cost of laser dentistry;
- 2) rarely used in municipal institutions;
- 3) inability to use laser technologies for neoplasms, diabetes, vascular diseases, tuberculosis and pathological changes in blood composition.

High cost? Maybe the problem is that the authors of the article use helium-neon lasers that have not been used for many years, since it is very expensive and requires difficult maintenance. Modern laser devices are much more efficient, maintenance-free and have no additional costs, it's paid off within a maximum of a month, even when procedures are priced at a minimum.

Indeed, laser therapy, unfortunately, is not so often used in municipal institutions, as it would be desirable, firstly for patients. But this is not a “minus” of the method, but the result of state “regulation” in the health care system. Instead of a simple, inexpensive and highly effective method of treatment, which should be highly recommended to everyone, “health care organizers” more often offer expensive and inefficient treatment. Otherwise officials would not “earn” any money. As a result of such “optimization”, there are significant, sometimes insurmountable, obstacles for the development of laser therapy.

It is also necessary to say a few words about the ineradicable desire by some to use the notorious “dose”, instead of setting the normal parameters of the laser therapy technique: wavelength, operating mode and power of LILI, frequency for pulsed lasers, exposure, etc. This absolutely meaningless term is often used together with “irradiation”: another concept that is completely inconsistent with reality. Laser light fundamentally does not differ from a solar or illumination lamp, except for monochromaticity (one wavelength), the laser shines just like a flashlight, and the laser beam is illuminated by the impact site. “Irradiation” is only done by ionizing, radioactive light. The phrase “irradiate with a dose” frightens many patients and medical personnel, so using this terminology is a sure sign of unprofessionalism. Although it should be recognized that many are just not yet accustomed to, have not mastered, did not have time to disaccustom from bad habits, but let's hope that they have everything ahead of them.

It is necessary to shine, light, conduct lighting, or influence LILI, as well as set all the parameters of the technique without exception. These simple rules will provide an absolutely safe and effective treatment.

Calculating the “dose” and energy is harmful for your health

As it turns out, the question is not idle. We must constantly return to this topic, which is largely due to the rather active advertising by some unscrupulous producers of a function such as “dose control” or “energy calculation”. In fact, such a “service” can become a “bearish service” for the patient, since it sharply increases the probability of error on the part of personnel, and leads to negative consequences resulting from improper application of the technique.

It is necessary to understand and accept once and for all that such an abstract quantity as the “dose” (“energy”) indicated in the methods only harms the development of laser therapy as a controlled, reproducible, safe and effective method of treatment.

In the medical chart, when setting a procedure, ALL parameters of the procedure should always be indicated, this is necessary for a controlled and reproducible process of treatment. There should not be a single word about the “dose”, otherwise everything comes down to one simple recommendation – “to work on the place that hurts, with a dose of $1\text{J}/\text{cm}^2$ ”, as it is done in some manuals [Ponomarenko G.N., Vorobiev M.G., 2005] (by the way, the authors, to their credit, acknowledged their mistake and no longer publish such “techniques”).

Excessive information in the form of additional indications of a photometer or calculations with a subsequent indication is detrimental to the effectiveness of laser therapy, since it only distracts from work and introduces confusion in the process of optimizing the parameters for an effective technique!

Even more so, in the system of units of measurement *there is not a word about a “dose”, and using this term in laser therapy simply violates the law!* There is energy, measured in J, and energy density (ED), measured in J/cm^2 . We constantly say that it is necessary to exclude the terms “irradiate” and “dose”, frightening patients and medical personnel unreasonably and also not corresponding to the accepted units of the in publications on laser therapy and in practical daily communication.

In the medical chart, when setting the procedure for monitoring, ALL the parameters of the procedure must be specified separately: wavelength, operating mode, power, exposure time, exposure area (method of action), and frequency for pulsed lasers.

Why is it HARMFUL for EFFECTIVE laser therapy (sometimes for patients), if the device counts the notorious “dose” or energy? Let’s demonstrate in different variants the parameters of the method.

Option 1: The ED may be the same (most often the optimal $1\text{J}/\text{cm}^2$) in three different situations (assuming a contact-mirror technique and an effective area of 1cm^2):

- 1) the power of 1mW is multiplied by the exposure time 1000 seconds (about 15 mins) = $1\text{J}/\text{cm}^2$;
- 2) the power of 1000mW is multiplied by the exposure time 1 second = $1\text{J}/\text{cm}^2$;
- 3) the power of 10mW is multiplied by the exposure time 100 seconds (about 1.5 minutes) = $1\text{J}/\text{cm}^2$.

But the effect, i.e., a positive result of the treatment, will be ONLY in the 3rd case, when all the optimal parameters are given, and even then, only for lasers of continuous operation with a wavelength of 635nm (red spectrum). In options 1 and 2, there will be no curative effect for any laser or mode of operation! This is a consequence of the nonlinearity of the ratio of these parameters, since the exposure time associated with the period of 100 seconds of the propagation of waves of increased Ca^{2+} concentration in cells and tissues is the determining factor [Moskvin S.V., 2008].

Option 2: If you use lasers with different wavelengths, then the effect with a formally identical “dose” will be completely different! For example, it is known that for the ILBI-635 (wavelength 635nm, red spectrum, power 2mW), the optimum exposure time is 15–20 minutes. If such an exposure is chosen for the effect of LILI with the same power (1–2mW), but with a wavelength of 365nm (UV spectrum), there will be an overdose, and negative consequences are almost guaranteed. In this case, the device shows that everything is fine, the “dose” is exactly as the one given in the “recommendations”.

Option 3: Imagine that the process of calculating the “dose” is started, but at the same time forgetting to turn on the desired channel or not removing the protective cover from the illuminating attachment, or maybe just forgetting to place the laser head in the right place. What then? Formally, the calculation of the “dose” is optimal, the indicator is good, but what will the result be? The answer is obvious, discrediting the method.

The final result is affected by all parameters of the technique individually: wavelength, operating mode, power, exposure time, frequency and technique. Only when they are assigned consistently, controllably and correctly in their totality, can we speak about the predictability and reproducibility of the result obtained. By following these parameters, the maximum effect of laser therapy is achieved. Any additional calculations or multiplications distract from normal operation!

The calculation of the “dose” on the device is exclusively a marketing move, only allowing unfair producers to get additional profit, while creating problems for the medical staff and patients. An unnecessary indication reduces the effectiveness of treatment, thereby increasing the likelihood of error during the procedure. Companies that produce such devices should be treated with caution (at least), amateurs work there who do not understand what they are doing, they do not know the basic normative documents (standards) and do not think about the consequences of their illiteracy.

In the designation, all parameters of the technique should always be indicated: wavelength, operating mode, power, exposure time, exposure area (method of action), and frequency for pulsed lasers. A small exception for the ILBI when only three parameters are set: wavelength, power and exposure, since continuous LILI without modulation is used almost always and the access method is always known.

Thus, real, and not imaginary, contraindications for laser therapy are the non-professionalism of the method and the phobia in the patient, and for particularly difficult conditions, the choice is left to the specialist.

THEORETICAL AND METHODOLOGICAL ASPECTS OF PAIN MANAGEMENT BY LASER LIGHT

The chapter in the book based on pain in general, and the mechanisms of its influence on it is due to the complexity of a large number of relevant LT techniques. Since the pain syndromes and the causes of their occurrences are extremely diverse, differentiation and methods of laser action are required. In addition, it is necessary to provide research data on the mechanisms of the action of LILI on the nervous system as a whole, and its nociceptive component in particular, that is, to provide a theoretical basis for the methodology of laser therapy aimed at reducing pain.

An interesting, even paradoxical situation has developed in the fact that there are not a lot studies on this topic in scientific literature. Studies rarely focus on this issue, but there are well-developed and effective methods of laser illumination therapy. Clinicians do not set themselves the goal to quickly eliminate pain syndrome, quite rightly suggesting instead, the natural disappearance of pain is a result of the patient's *recovery*.

On the other hand, there are many international studies devoted to the study of the analgesic effect of LILI, and interesting results have been obtained, which largely clarify the mechanisms through which this process is realized. However, effective laser therapeutic methods for pain management have not yet been proposed. Although the word combination used in English literature is much deeper than the unambiguous concept of “anaesthesia” and better characterizes the very essence of the methodology in this aspect – not simple (direct) suppression of pain, but through influence on the various mechanisms that cause it.

Earlier we repeatedly turned to this topic [Kochetkov A.V., et al., 2012; Moskvina S.V., 2014, 2016], but the dynamic development of the direction constantly make adjustments, new links to studies are added, more detailed analysis is carried out, the methodology of laser therapy as a whole and its individual methods are adjusted.

Classification of pain syndromes [by A.M. Wayne et al. (1999)]

Pain is a concept that is clinically and pathogenetically complex and heterogeneous. It differs in intensity, localization and subjective manifestations (shooting, pressing, pulsing, pricking, cutting, whining, etc.), can be permanent or periodic. All the existing variety of pain characteristics are largely due to the very cause that caused them, the anatomical region in which a nociceptive impulse arises. This is very important for determining the cause of pain and subsequent treatment. One of the most significant factors in understanding this phenomenon is the division of pain into acute and chronic.

Pain is a warning signal about disorders occurring in the body, which opens the way to the recognition and treatment of many diseases. In this sense, pain is an important and useful sensation.

In this situation, one should keep in mind that the feeling of pain is a resultant reciprocal relationship between nociceptive and antinociceptive systems, which are individual and determined by both genetic and acquired factors. There are highly sensitive to painful irritations, “painful” personalities and people who have a high pain threshold. In addition, the fact that the perception of pain is a psychophysiological process must also be recognized. Pain is always coloured by emotional experiences, which also gives it an individual character. The most important factors are the emotional and personal characteristics of the subject, the level of his neuroticism, depressive-hypochondriacally-sensopathic manifestations. It is essential that the antinociceptive systems and the mental state closely interact with each other due to anatomical-functional and neurochemical connections. In close interaction, they determine the levels of pain susceptibility and the characteristics of pain experience.

In recent years, special attention is drawn to what is called chronic pain. The main characteristic is a prolonged, often monotonous manifestation of pain, which is often not strictly localized, but diffused and widespread. In such patients, the headache is combined with pains in the back, limbs, abdomen, etc. “Everything hurts” – they determine their condition like so. Quite often, the disease immediately manifests itself as a widespread pain syndrome, sometimes different parts of the body are gradually involved, and in some cases, chronic pains are formulated alongside already existing acute local pains. But even in the latter situation, the disease detaches from the specific pathological processes that cause acute pains, and already exists according to its own patterns. The chronic pains that are formed in patients often lose any useful signal significance. In a number of cases it becomes obvious that the basis for their appearance is the mental factor, and they can be referred to as psychogenic. The leading pathological algorithm, as a rule, is depression, hypochondria or shemostopathy. Sometimes this syndrome is referred to as depression or pain. This category of patients seems complicated. Constant calls to doctors, a long search for organic causes of pain, numerous invasive methods of research and even surgical interventions (a number of patients have Munchhausen’s syndrome, when they persistently encourage the doctor to conduct new research or interventions) – this is how the life of these patients proceeds.

Of course, not all chronic pain in patients is due to mental disorders. Oncological diseases, joint damage and other diseases are accompanied by chronic, but more often localized pain. Although it is necessary to take into account the possibility of a depression-pain syndrome alongside this.

A special place among pain syndromes is occupied by visceralgias, i.e., pain associated with the pathology of internal organs, the innervation of which is provided by the autonomic nervous system. It is now clear that the central apparatuses, conducting, analysing and suppressing pain, are common to the autonomic and somatic nervous systems. But the management of pain in the autonomic nervous system remains the subject of study and discussion to this date. It should be emphasized that autonomic pain (vegetation) is not limited to visceralgia, and can be manifested by sympathetic syndromes on the face, extremities and trunk.

The appearance of a pain symptom or syndrome is always a signal of danger, requiring urgent help. Certainly, this refers to situations of acute pain. The doctor’s

task is to determine the cause of pain, to develop optimal and rational ways to ensure adequate analgesia. There are several ways. Analgesic drugs are widely used in clinical practice, and their action is aimed at reducing the activity of the nociceptive system and stimulating antinociceptive systems. There are other ways of stimulating antinociceptive systems: percutaneous electroneurostimulation (PENS), acupuncture, laser therapy, etc. In the most difficult and severe cases, it becomes necessary to use various surgical methods for pain relief. A special method, especially for chronic pain, is the use of psychotropic drugs (antidepressants, tranquilizers, etc.), which, based on the potentiation effect, in conjunction with analgesics, can significantly improve the results of analgesic therapy. The success of the fight against pain also depends on the solution of organizational problems. All over the world, there are specialized multidisciplinary centres to combat pain. Practically in all civilized countries there are associations to combat pain, coordinating the scientific and practical activities of doctors in this direction. Annual international and national congresses are held, discussing the problems of pain in its various aspects, which proves the urgency of in-depth study for the problems of anaesthesia in a broad medical plan.

Pain occurs as a result of irritation of the peripheral receptors and through the afferent systems reaching the thalamic relay, continuing on the path to the cortical systems. The basic anatomical pathways can be referred to specific brain formations, and are referred to as the spinothalamic pathway. However, it is shown that it is not homogeneous, and a certain part of it, designated as a neospinothalamic tract, has as its target a system of reticular formation of the brainstem, hypothalamus, limbic system. They are the main functional nodes of the so-called nonspecific brain system that provide emotional, autonomic, endocrine support for the sense of pain. Some of these systems are included in the antinociceptive system, the level of functioning of which determines the degree of pain syndrome. On the other hand, descending systems of the limbic-reticular complex modulate the level of sensitivity of pain receptors, bringing them in line with the actual behaviour of a person (for example, a decrease in the level of perception of pain in extreme conditions).

The neurology of nonspecific brain systems traditionally considers many sensorimotor and autonomic-endocrine syndromes as psychomotor, psychosensory and psychovegetative. In terms of psychosensory relations, an important idea is to consider the phenomenon of pain in close connection with emotional, anxious, hypochondriacal disorders, and also the role of emotional distress as a factor of initiating pain sensations and their supports. The relationship between mental disorders and pain is not simple and unambiguous. Being very closely related to each other by cause-effect relationships, they unite in their biological basis. First of all, we are talking about neurochemical mediator features of the brain. Along with the great role of morphine-like active biological substances, the serotonergic systems of the brain are put forward, followed by the relations of “glutamate-GABA”, and, more recently, nitric oxide (NO). The importance of these concepts, in particular the problem of “depression – pain”, is important in determining the course of pain syndromes, which cannot be overestimated.

From the neurology of nonspecific brain systems, functional neurology was born, the main postulate of which is the examination and establishment of the connection of

neurological symptoms with the functional state of the brain in the “sleep-wakefulness” cycle. Many pain syndromes are “attached” to certain conditions. Often there is a modulation of pain between the active intense wakefulness and the relaxed “sleep” state, and there are many variants of this relationship. There are pains, mainly manifested either in a state of wakefulness, or in a dream. The latter make up the “sleep medicine” section. The close relationship between the functional state of the brain and the character, the severity of the pain syndrome, in addition to an important aspect of understanding the nature of pain, opens the prospect of organizing the treatment of pain of this kind. Already, we can talk about the possibilities of biological feedback, sleep regulation, chrono-pharmacotherapy.

Pain syndromes are distributed unevenly among people, and depending on gender, the degree of this “discriminatory inequality” is specific for different variants of pain syndromes. In general, pain is the unfortunate privilege for women, although sometimes there are inverse relationships. Obviously, how much can this analysis give to an understanding of the essence of the pain phenomenon, in which endocrine, emotional, social, and cultural factors play a role, up to the features of brain mediation.

Another feature of the view of neurological pathology is the constant attention to complete or partial lateralization of the process. The pains can be bilaterally symmetrical, they can predominate on one side or they can be exclusively one-sided. The latter can be the result of both the involvement of the peripheral nervous system (neuralgia, lumboschialgia, cluster pain, etc.) and central, in particular thalamic pain. A sufficient number of studies have shown that lateralized pains are not clinically identical, that they manifest with varying frequency on the left and right halves of the body. And this aspect is rarely taken into account in the practical work of the neurologist. The causes of lateralization are functional asymmetry of the brain, referring to the patient as a right-handed or left-handed person, a different width of bone channels, shortening of one of the legs, skewing of the pelvic or shoulder girdle. Evaluation of the above facilitates the understanding of certain links of pathogenesis in a specific clinical situation and the development of adequate therapeutic measures.

A.M. Wayne et al. (1999) consider that when examining the pain syndrome, it is necessary to evaluate not only the localization, the nature of pain, the type of acute and chronic pain, nociceptive and neuropathic, which is an obligatory program for studying patients of this category, but also to consider the emotional-personal characteristics and dynamics of pain in various functional states of the “sleep – wakefulness” cycle, taking into account the sex/gender and side of the lesion. The patient, having come to the doctor, says that he has a headache (face, chest, back, etc.). From this begins the analysis of pathology with the mandatory transition to the third stage – the designation of the disease itself. Such an approach is fundamentally important for the choice of laser therapy techniques, which can differ in a completely principled way depending on a variety of factors.

On the basis of pathophysiological mechanisms, it is suggested to distinguish between neuropathic and nociceptive pain [Wayne A.M., et al., 1999]. From the point of view of the methodology of laser therapy, it is preferable to introduce the concepts of primary and secondary pain syndromes, respectively. In the first case, the effect of LILI

is directed straight at the nervous system, and in the second – upon the elimination of the true cause of the disease, when the easing of the pain syndrome occurs due to the elimination of the pathological process (e.g., inflammation).

Nociceptive pain occurs when the tissue-damaging stimulus acts on the peripheral pain receptors. The causes of this pain can be a variety of traumatic, infectious, dysmetabolic and other damaging things (carcinomatosis, metastases, retroperitoneal neoplasms) that cause the activation of peripheral pain receptors. Nociceptive pain is most often an acute pain, with all the characteristics inherent in it. As a rule, the pain stimulus is obvious, the pain is usually well localized and easily described by patients. Nevertheless, visceral pain, localized and described less clearly, as well as reflected pain, is also referred to as nociceptive. The appearance of nociceptive pain as a result of a new injury or disease is usually habitual for a patient and is described by him in the context of previous pain sensations. For this type of pain typicality is their rapid regression after the cessation of the damaging factor and the short course of treatment with adequate analgesics. It should be emphasized, however, that prolonged peripheral irritation can lead to the dysfunction of central nociceptive and antinociceptive systems at the spinal and cerebral levels, which necessitates the fastest and most effective elimination of peripheral pain.

Pain resulting from damage or changes in the somatosensory (peripheral and/or central) nervous system is referred to as neuropathic. It should be emphasized that this is a pain that can occur in violation not only in peripheral sensory nerves (for example, in neuropathies), but also in the pathology of the somatosensory system at all levels – from the peripheral nerve to the cerebral cortex. Below is a short list of the causes of neuropathic pain, depending on the level of damage (Table 15). Among the presented diseases, it is necessary to note the forms for which the pain syndrome is the most characteristic and occurs more often. These are trigeminal and postherpetic neuralgia, diabetic and alcoholic polyneuropathies, tunnel syndromes, syringobulbia.

Neuropathic pains are much more diverse than the nociceptive pains in their clinical characteristics. This is determined by the level, vastness, nature, duration of the lesion, and many other somatic and psychological factors. With different forms of damage to the nervous system, at different levels and stages of development of the pathological process, the involvement of different mechanisms of the genesis of pain may also be unequal. However, always, regardless of the level of damage to the nervous system, both peripheral and central mechanisms of pain control are included.

Common characteristics of neuropathic pain are persistent nature, long duration, ineffectiveness of analgesics for its relief and a combination of autonomic symptoms. Neuropathic pains are more often described as burning, stitching, aching, or shooting.

Neuropathic pain is characterized by various sensory phenomena: paraesthesia – spontaneous or sensory sensation; dysesthesia – unpleasant, spontaneous or induced sensations; Neuralgia is pain that spreads over one or more nerves; Hyperesthesia – hypersensitivity to ordinary pain stimulus; Allodynia – perception of non-bellucose irritation as pain; Hyperalgesia – an increased pain response to pain stimulus. The last three concepts used to describe hypersensitivity are combined by the term “hyperpa-

Levels of damage and causes of neuropathic pain

Level of damage	Causes
Peripheral nerve	Injuries Tunnel Syndromes Mononeuropathy and polyneuropathy: – Diabetes – Collagen diseases – alcoholism – amyloidosis – hypothyroidism – uremia – isoniazid
Spine and posterior horn of spinal cord	Compression of the root (disk, etc.) Postherpetic neuralgia Trigeminal neuralgia Syringomyelia
Spinal Cord Conductors	Compression (trauma, swelling, arteriovenous malformation) Multiple sclerosis Deficiency of vitamin B12 Myelopathy Syringomyelia Hematomyelia
Brain trunk	The Wallenberg-Zakharchenko Syndrome Multiple sclerosis Tumors Syringobulbia Tuberculoma
Thalamus	Acute cerebrovascular accident (stroke) Tumors Surgical operations
Cortex	Acute cerebrovascular accident (stroke) Tumors Arteriovenous aneurysms Craniocerebral trauma

thy". One of the types of neuropathic pain is causalgia (a feeling of intense burning pain), which occurs most often in a complex regional pain syndrome.

Mechanisms of neuropathic pain in the lesions of the peripheral and central links of the somatosensory system are different. The proposed mechanisms of neuropathic pain in peripheral lesions include: post-provender hypersensitivity; the generation of spontaneous painful impulses from ectopic foci formed during the regeneration of damaged fibres; the Ephaptic transmission of nerve impulses between demyelinated nerve fibres; Increased sensitivity of the neuron of damaged sensory nerves to noradrenaline and some chemical agents; Reduction of antinociceptive control in the hindquarter in the lesion of thick myelinated fibres. These peripheral changes in the afferent pain flow lead to shifts in the balance of the overlying spinal and cerebral apparatus involved in the control of pain. At the same time, cognitive and emotional-affective integrative mechanisms of perception of pain are obligatory to be included.

One of the variants of neuropathic pains is those that arise when the central nervous system is affected – the “central” ones. In this type of pain, there is a complete, partial or subclinical disorder of sensorimotor sensitivity, most often associated with spinal cord injury at the spinal and/or cerebral levels. However, it should be emphasized here that the peculiarity of neuropathic pain, both central and peripheral, is the absence of a direct correlation between the degree of neurologic sensory deficiency and the severity of the pain syndrome.

If the sensory afferent systems of the spinal cord are damaged, the pain may be localized, one-sided or diffused bilaterally, and may capture the zone below the level of the lesion. The pains are constant and have a burning, stitching, tearing, sometimes cramping characteristics. Alongside this, there may be various paroxysmal focal and diffused pains of this nature. An unusual pattern of pain is described in patients with a partial lesion of the spinal cord, its anterolateral regions: when pain and temperature stimuli are applied in the area of sensation loss, the patient feels them in appropriate zones contralaterally on the healthy side. This phenomenon was called “allochuria” (“the other hand”). The well-known symptom of Lermitt (paraesthesia with elements of dysesthesia during movement in the neck) reflects the increased sensitivity of the spinal cord to mechanical influences in conditions of demyelination of the posterior columns. Data on similar manifestations in the demyelination of spinothalamic pathways is not currently available.

The mechanisms of central pain are quite complex and not fully understood. Recent studies have demonstrated the functional plasticity of the central nervous system in lesions at various levels. The obtained data can be grouped as follows. The defeat of the somatosensory system leads to disinhibition and the appearance of spontaneous activity of deafferented central neurons at the spinal and cerebral levels. Changes in the peripheral link of the system (sensory nerve, posterior root) inevitably lead to a change in the activity of thalamic and cortical neurons. The activity of deafferented central neurons changes not only quantitatively, but also qualitatively: under the conditions of deafferentation, the activity of some central neurons that do not previously have a relationship to the perception of pain begins to be perceived as such. In addition, in the conditions of the “blockade” of the ascending pain flow (damage to the somatosensory pathway), the afferent projections of the neuronal groups at all levels are violated (horns, trunk, thalamus, cortex). In this case, new ascending projection paths and corresponding receptive fields are formed quite quickly. Since this process occurs very quickly, it is most likely not formed, but opens up a spare or “disguised” (inactive in a healthy person) way. It may seem that in the conditions of pain, these shifts are negative. However, it is postulated that the meaning of such an “aspiration” for the mandatory preservation of the flow of nociceptive afferentation lies in its necessity for the normal operation of antinociceptive systems. In particular, with the defeat of pain afferentation systems, the insufficient effectiveness of the descending antinociceptive system of the near-conductor substance, the large core of the seam and the diffused nociceptive inhibitory control are associated. The term “deafferentation pain” refers to the central pain that occurs when afferent somatosensory pathways are affected.

In most cases, specialists face a mixed type of chronic pain, which greatly complicates the choice of treatment tactics and makes it difficult to predict a full recovery. A number of specialists, probably for this reason, add another variant to the two types of pain: “psychogenic pain”, characterized by the following signs: incompatibility of complaints and objective signs of pain, non-localized nature of pain and its migration, ineffective treatment and numerous “crises” [Shostak N.A., Pravdyuk N.G., 2012]. One should agree with the authors of this publication, that pain-related clinical syndromes represent an important interdisciplinary health problem, which confirms the advisability of an integrated approach to its diagnosis and treatment, but also to consider the ineffectiveness of treatment as a criterion for the absence of physiological causes of the problem is somehow too pessimistic.

Yes, it is known, for example, that the patient’s mental and emotional state plays an important role in the pathogenesis of fibromyalgia, after all, the CNS takes part in the pathogenesis of all pain syndromes [Danilov A.B., Kurganova Y.M., 2012], but also in the existence of other, physiological and biochemical disorders. Therefore, almost all specialists agree that the problem can be solved only by the result of an integrated approach, using simultaneously different methods of treatment.

Phantom pains stand somewhat apart from the others, as opinions of experts often differ on this topic. We quote one interesting book that contains evidence of the effectiveness of physiotherapy in the rehabilitation of cancer patients, including the following syndrome: “Since physiotherapy is unanimously excluded from the rehabilitation of this contingent of patients – sedatives, tranquilizers, analgesics, narcotic analgesics and novocain blockades are used commonly” [Grushina T.I., 2006], let me ask, why is it “unanimously excluded”? Is the problem is solved easily by the use of pharmaceuticals only, and without consequences for the patient? No. But there are a lot of studies that allow us to confidently say that various physiotherapeutic methods, including laser therapy, can effectively treat patients with phantom pains [Berglezov M.A., et al., 1998; Grushina T.I., 2006; Degtyareva A.A., Zubova N.D., 1999; Shcherbenko O.I., et al., 2010; Ebid A.A., El-Sodany A.M., 2014; Ribas E.S.C., et al., 2012].

Certain pathophysiological features of neuropathic and nociceptive pain were revealed. Special studies have established that the effectiveness of opioids is much higher in nociceptive than in neuropathic pain. This is due to the fact that with nociceptive pain, the central mechanisms (spinal and cerebral) are not involved in the pathological process, whereas with neuropathic pain there is direct suffering. The analysis of the works devoted to the study of the destructive effects (neurotomy, rhizotomy, chordotomy, mesencephalotomy, thalamotomy, leukotomy) and stimulation methods (PENS, acupuncture, stimulation of the posterior rootlets, grey matter, thalamus) in the treatment of pain syndromes allows the following conclusion: If the blocking of the nerve pathways, regardless of their level, is most effective in stopping nociceptive pain, stimulation methods, on the contrary, are more effective in neuropathic pain. However, leading in the implementation of stimulation procedures are not opiates, but other, yet unspecified, mediator systems.

There are differences in the approaches to drug treatments for nociceptive and neuropathic pain. For the relief of nociceptive pain, depending on its intensity, non-narcotic

and narcotic analgesics, non-steroidal anti-inflammatory drugs (NSAID's) and local anaesthetics are used. In the treatment of neuropathic pain, analgesics are generally ineffective, drugs from other pharmacological groups should be used. For treatment of patients with chronic neuropathic pain, the drugs of choice are antidepressants (tricyclic antidepressants, serotonin reuptake inhibitors) that enhance serotonergic activity. The use of these drugs is due to the inadequacy of serotonin brain systems in many chronic pains, usually associated with depressive disorders.

In the treatment of various types of neuropathic pain, several anti-epileptic drugs are widely used, such as anticonvulsants [Amelin A.V., et al., 2007]. The exact mechanism of their analgesic effect remains unknown, but it is postulated that the effect of these drugs is related to: 1) stabilise the neuronal membranes by decreasing the activity of voltage-dependent sodium channels; 2) activate GABA system; 3) inhibit NMDA receptors. Currently, NMDA receptor antagonists are not widely used in the treatment of pain syndromes due to the numerous adverse side effects associated with the participation of these receptors in the realization of mental, motor and other functions. Certain hopes are associated with the use of drugs from the amantadine group (used in Parkinson's) for chronic neuropathic pain, which, according to preliminary studies, have a good analgesic effect due to the blockade of NMDA receptors.

Drugs with anxiolytic effects and neuroleptics are also used in the treatment of neuropathic pain. Tranquilizers are recommended mainly for severe anxiety disorders, and neuroleptics – for hypochondriacal disorders associated with pain syndromes. Often, these are used in combination with other drugs.

Central muscle relaxants with neuropathic pain are used as drugs that strengthen the GABA system of the spinal cord, and along with muscle relaxation, have an analgesic effect. Applies to post herpetic neuralgia, complex regional pain syndrome and diabetic polyneuropathy.

In a number of new clinical studies for the treatment of patients with chronic neuropathic pain, it is proposed to use drugs that affect the operation of sodium-potassium channels in the peripheral nerve.

Special clinical studies have shown that with neuropathic pain, the level of adenosine in the blood and Cerebrospinal fluid is significantly lower than in the norm, whereas with nociceptive pain the level does not change. This data indicates the insufficient activity of the purine system for neuropathic pain and the adequacy of adenosine administration in such patients.

One of the directions in the development of the effective removal of neuropathic pain is to study the potential of calcium channel blockers.

The role of the immune system in the initiation and maintenance of neuropathic pain has been demonstrated in experimental studies [Arruda J.L., et al., 1998]. It has been established that when peripheral nerves are damaged in the spinal cord, cytokines (IL-1, IL-6, TNF- α) are produced, which promote the persistence of pain, and the blockade of these cytokines reduces pain. With the development of this area of research, new perspectives in the development of medicine for the treatment of patients with neuropathic chronic pain are associated [Vetrile L.A., 2007].

Experimental and clinical studies on the mechanisms of the analgesic action of laser light

Unlike drugs with a specific action, LIL affects not only one link in pain reception, but practically the entire hierarchy of its regulatory mechanisms. This is the absolute advantage of laser therapy, with the potential to effectively apply the method in a variety of types of pain and etiology [Fulop A.M., et al., 2010]. However, the choice of the parameters of the method is very difficult. To justify effective regimes, it is necessary to understand the effect that laser light has on the underlying acting mechanisms and directly on the nervous system itself.

It is known that calcium ions regulate peripheral pain sensitivity through modulation of ATP-induced interaction with the P2 family of surface pain receptors, with control being shown by both the peripheral and central nervous system. A change in the concentration of calcium ions controls the work of virtually all pain components, from the physiological mechanisms of its formation to the transmission of nerve impulses and complex regulatory processes [Berridge M.J., et al., 2000; Burgoyne R.D., 2007; Burnstock G., Wood J.N., 1996; Cesare P., McNaughton P., 1997; Cook S.P., McCleskey E.W., 1997; Kress M., Guenther S., 1999; Palecek J. et al., 1999; Ralevic V., Burnstock G., 1998; Song S.O., Varner J., 2009]. Recall that the primary act of the biological effect of LILI is also the thermodynamic launch of Ca^{2+} -dependent processes. That is, laser light can directly regulate nociceptive mechanisms. Together, these facts make it possible to explain the many effects of laser illumination, and to predict the most optimal parameters of the technique.

When choosing LILI parameters, the localization and size of the light spot is crucial. The effect on the acupuncture point E36 (zu sang li) and the projection of the deep peroneal nerve (nervus fibularis profundus) of infrared LILI causes analgesia, typical for an intravenous injection of naloxone. It is shown that this result is achieved by increasing the pain sensitivity threshold and releasing endogenous opiates [Bian X.P., et al., 1989]. The threshold of pain sensitivity also increases after exposure to TA GI11 (qui chi) LILI in the red region of the spectrum (633nm), however, the authors of the study consider this effect only as a consequence of changes in skin blood flow [Phandech K. et al., 2008].

An analgesic effect in experiments is observed also in transcranial illumination of infrared LILI (820nm, modulated mode, frequency 1000Hz, optimal ED 12J/cm²), both alone and in combination with naloxone (0.5 and 10mg/kg). LILI enhances the action of naloxone, which, in the opinion of several authors, confirms the opioid mechanisms of the analgesic effect of laser light [Hagiwara S. et al., 2008; Navratil L., Dylevsky I., 1997; Wedlock P.M., Shephard R.A., 1996].

Numerous studies have convincingly proved that the effect of LILI contributes not only to an increase in the synthesis and release of endorphins [Basford, J.R., 1986; Gibson K.F., Kernohant W.G., 1993; Laakso E.L., et al., 1994; Rico F.A., et al., 1994], but also a reduction in the level of neurotransmitters of nociceptive receptors such as bradykinin and serotonin [Gur A. et al., 2003, 2003⁽¹⁾; Jimbo K. et al., 1998; Walker J.B., 1983]. However, in a number of works, this mechanism is questioned due to

the short duration, anaesthesia is maximally limited only in the period between the 5th and 20th minutes [Pozza D.H., et al., 2008]. This is probably just one of the mechanisms, the fastest response of a complex pain management system, which, of course, is essential in forecasting the development of the effect.

“This method has had a very rapid effect on the sciatic pain,” wrote N.R. Finsen (1901), meaning the direct illumination of the sciatic nerve with blue light. Now this is quite often used in model experiments, that this region is illuminated, but already LILI has different wavelengths.

Laser illumination (transcutaneously at the points of the hind limbs that lie over the sciatic nerve in rats) in the visible (650nm) and infrared (808nm) spectra reduces the proximal amplitudes and increases the delay time of somatosensory evoked potentials (SSEP) and the composite muscle action potential up to 20 minutes (CMAP). All changes for both wavelengths return to the baseline level after 48 hours. This data supports the hypothesis of the direct influence of LILI on nerve conduction, often such a mechanism underlies the clinical effectiveness of laser illumination in pain syndromes [Chow R., et al., 2012; Chow R.T., et al., 2007; Yan W., et al., 2011].

This conclusion is supported by numerous studies [Iijima K. et al., 1991⁽¹⁾; Palmgren N., et al., 1989), the laser-induced stabilization of cell membranes regulates the transmission of nerve impulses, inhibition of ATP synthesis, which generally contributes to a significant increase in the delay in the transmission of nerve impulses, respectively, and the signal of the onset of pain [Cambier D., et al., 2000; Chow R.T., et al., 2007; Ebert D.W., Roberts C., 1997; Greco M. et al., 2001; Maegawa Y. et al., 2000; Snyder-Mackler L., Bork C. E., 1988]. An increase in the pain sensitivity threshold due to the modulation of nerve impulse transmission has been discussed by many authors [Mendez T.M., et al., 2004; Ohshiro T., Calderhead R.G., 1991; Walker J., 1983]. In this case, not only the blocking of nociceptive signals in the primary afferent neurons occurs [Jimbo K. et al., 1998], but there are specific features in the development of the response. For example, laser illumination pulp of infrared LILI (830nm) suppresses the late response in caudal neurons caused by an exciting signal from the C-afferents, but does not affect the early impulses from the A δ -fibres. This means that LILI inhibits the excitation of unmyelinated pulp fibres without affecting the fine myelinated fibres [Wakabayashi H., et al., 1993]. A similar effect was also obtained when exposed to the tooth channel by light from an Er: YAG laser (2940nm, frequency 10Hz, 0.1J/cm²) for 10 minutes [Zereto J.L., et al., 2005].

Many authors in clinical studies have found a correlation between the attenuation of pain and the serotonergic mechanism of its regulation [Mizokami T. et al., 1993]. Using double-blind control, it was shown that periodic exposure to red continuous LILI (633nm), even with minimum power (1mW), alleviates the suffering of patients with chronic pain. Analgesia in patients with trigeminal neuralgia, postherpetic neuralgia, in sciatica and osteoarthritis is observed after exposure to the skin in the projection of the outer radial, medial and subcutaneous nerves. There is a significant increase in urinary excretion of 5-hydroxyindoleacetic acid, the product of serotonin disintegrates [Walker J., 1983]. Similar biochemical changes are observed alongside an analgesic

effect after exposure to pulsed infrared LILI (904nm) in patients with chronic orofacial pain [Hansen H.J., Thorøe U., 1990].

Local illumination (635nm, 110mW, exposure 41 seconds, ED 3.76J/cm², and 945nm, 120mW, exposure 38 seconds, ED 3.8J/cm²) eliminates mechanical allodynia and hyperalgesia in mice induced by the venom *Bothrops moojeni* [Nadur-Andrade N. et al., 2014] and *Bothrops jararacussu* [Guimarães-Souza L. et al., 2011], which, in the opinion of some authors, is due to inhibition of the release of prostaglandin E2 (PGE2) [Sattayut S., et al., 1999]. It was also shown that the decrease in PGE2 levels and the inhibition of cyclooxygenase (COX-2) after LILI showed that effects are higher than that of steroid and NSAID's [Honmura A. et al., 1993; Sakurai Y., et al., 2000].

A significant analgesic effect is, in the opinion of some authors, a consequence of the suppression of excess activity of the sympathetic division of the ANS [Ide Y., 2009].

Another fundamental factor in the elimination of pain may be the known vascular effects of LILI. Increased blood flow increases oxygenation, lymphatic drainage, activity of neutrophils, macrophages and fibroblasts, as well as the exchange of defective or damaged cells. All this contributes to the elimination of pain, often after the first minutes after tissue illumination [Gur A. et al., 2004; Hakgüder A. et al., 2003; Ilbuldu E. et al., 2004; Maegawa Y. et al., 2000; Schaffer M. et al., 2000]. In the reduction of pain, the acceleration of arterial blood flow associated with the enhancement of synthesis and release of endothelial nitric oxide also plays a role [Brill G.E., Billill A.G., 1997; Samoilova K.A., et al., 2008].

In a recent study, the effect of low-intensity laser light on pain in two-month-old Wistar rats (males weighing 200–220g) with chronic compressed trauma was studied in various aspects. It is shown that the effect of LILI (904nm wavelength, pulse mode, 70W power, 9500Hz frequency, light spot area about 0.1cm², exposure 18 seconds per zone out of 9), starting from the second session, causes a decrease in allodynia, as well as thermal and mechanical hyperalgesia, which, according to the authors of the study, is due to the sharp inhibition of the significantly increased expression of interleukin 1-beta (IL-1 β) and fractalkine (ligand CX3 CR1 receptor) after trauma and a 50% reduction ($p \leq 0.001$) Glial fibrillar acidic protein (GFAP) of glial satellite cells of spinal ganglia (using immunoblotting and immunofluorescence techniques) [Oliveira M.E., et al., 2017].

Summarizing the above, let's briefly describe the physiological mechanisms underlying the analgesic effect of LILI:

- increases the threshold of pain sensitivity;
- changes in the levels of neurotransmitters of nociceptive receptors (bradykinin and serotonin) associated with activation of the GABA system;
- Release of endogenous opiates;
- reflex regulation mechanisms (laser acupuncture);
- stabilization of neuronal membranes, inhibition of ATP synthesis;
- increase in delayed somatosensory evoked potentials;
- decrease in the rate of signal transmission along sensory nerve fibres;
- suppression of excessive activity of the sympathetic nervous system;

- vasodilation, increasing oxygenation of tissues and enhancing lymphatic drainage;
- an anti-inflammatory effect, increased activity of neutrophils, macrophages and fibroblasts, acceleration of the exchange of defective or damaged cells;
- inhibition of mechanical allodynia and hyperalgesia
- inhibition of the expression of IL-1 β and fractalkine;
- decrease in the content of GFAP;
- spasmolytic action.

Schematically, some physiological processes that do not require additional comments are presented in Fig. 11–13 [Navratil L., Dylevsky I., 1997].

If we consider the data of various studies on the mechanisms of the analgesic effect of LILI in the physiology of pain, it is easy to understand that laser therapy can be effectively used to control both neuropathic and nociceptive type of pain.

A particular interest is the time intervals of “laser” analgesia, namely, the optimal exposure time and the time of aftereffect and the development of the response. It was shown that after the illumination with continuous red (660nm) and infrared (830nm) LILI, mice in the group with red spectrum showed statistically significant differences already in the first five minutes, and the effect lasted for a long time. Infrared LILI acts more slowly, during the first five minutes no significant differences were found, then the result accumulates, which provides better analgesia in a delayed period of time – up to 20 minutes. The authors of the study believe that the main mechanism for reducing

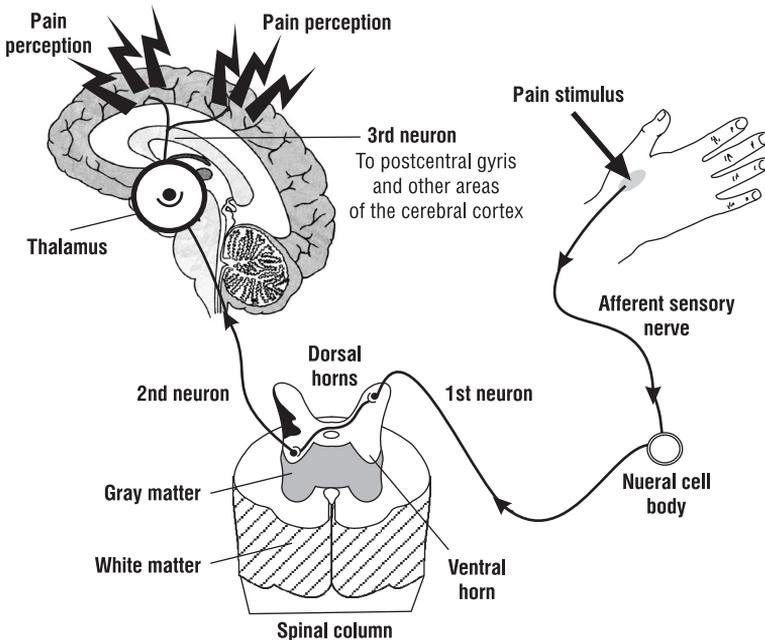


Fig. 11. Schematic representation of the way pain is transferred from the pain stimulus on the arm

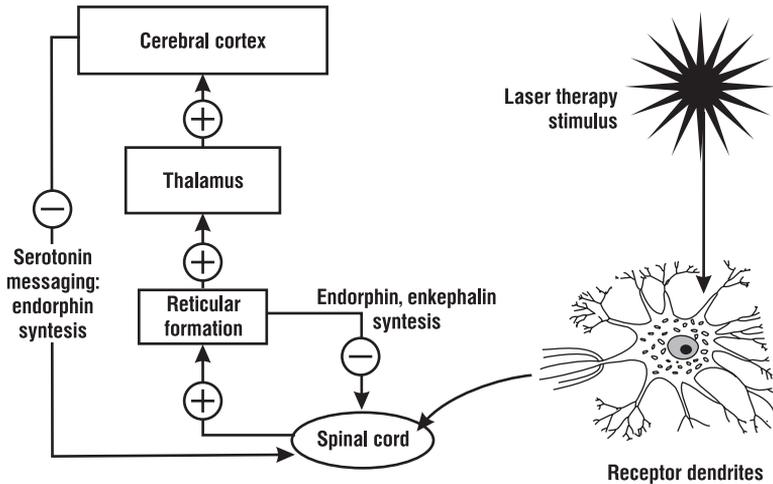


Fig. 12. A diagram illustrating the increase in the stimulating pattern and the counteraction of descending inhibitory pathways following laser stimulation of sensitive nerve endings (Navratil L., Dylevsky I., 1997)

pain in mice under the influence of LILI is a decrease in the rate of signal transmission through sensory nerve fibres [Pozza D.H., et al., 2008].

An analgesic effect of LILI with different parameters (wavelength, mode of operation, power density, exposure, frequency, technique) is shown in numerous animal studies [Pozza D.H., et al., 2008; Rico F.A., et al., 1994; Shaver S.L., et al., 2009; Wedlock P.M, Shephard R.A., 1996]. Illumination of cerebrospinal fluid (CSF) and blood with helium-neon (633nm) and AlGaAs (830nm) lasers increases the level of immunoreactive β -endorphins. Regardless of the wavelength of the laser source, the optimal ED in the study was a rather narrow range, from 9 to 10.8J/cm², and an increase in ED to 12J/cm² caused a statistically significant ($p < 0.001$) tendency to decrease the biological response. In this case, the periodically repeated exposure is more effective than single exposure [Rico F.A., et al., 1994].

A well-known universal analgesic technique for a variety of etiological causes is laser acupuncture [Baxter, G.D., 1989, 1994]. In general, the effect is carried out by the LILI of the red spectrum (633–635nm) with a power of up to 3mW using various schemes for both corporal and auricular AP. The course – 10–15 sessions every other day [Hu G.Z., 1989; King C.E., et al., 1990; Kroetlinger M., 1980; Naeser, M. A., 1997; Walker J.B., 1983; Walker J.B., et al., 1988; Waylonis G.W., et al., 1988; Wong T.W., Fung K.P., 1991]. Red laser light with a wavelength of 650–685nm [Litscher G., Schikora D., 2002] or infrared lasers with a wavelength of 830nm, power up to 10mW are used less often [Glazov G., et al., 2009].

Although there are many works confirming the effectiveness of anaesthesia of joint and back pain with continuous infrared lasers (830nm, 30–60mW) [Ohshiro T. et al., 1994; Shiroto C. et al., 1989, 1994, 1998; Toya S., et al., 1994], we recommend the use

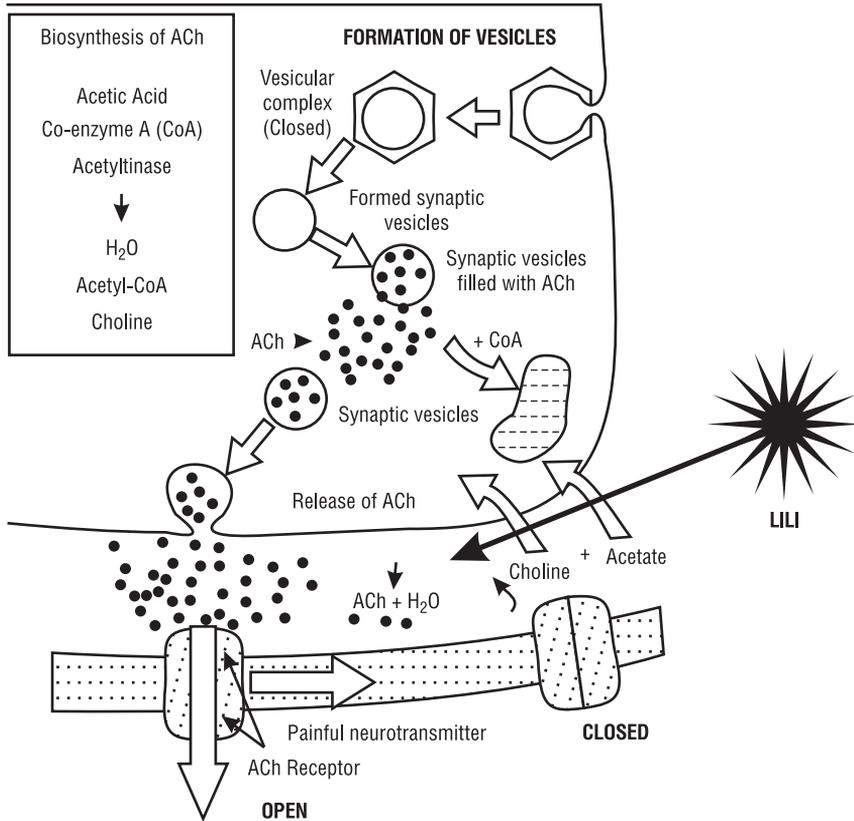


Fig. 13. In the left part of the diagram, an illustration of the biosynthesis of acetylcholine (ACh), a powerful pain neurotransmitter. Vesicles are formed by invading the membrane of the illuminated cell. After the shell is formed, the vesicles can freely grasp the synthesized cytoplasmic ACh, and then attach to the membrane where the ACh fuses and releases. In the case of an open synapse, acetylcholine finds nerve receptors and causes "pain". LILI inhibits the effect of ACh by deactivating the synthesis of acetylcholinesterase (AChE), an enzyme that accelerates the decomposition of ACh into choline and acetic acid, thereby preventing the transverse synaptic transmission of ACh (Navratil L., Dylevsky I., 1997)

of pulsed lasers only, since they allow for a wider range to vary with energy parameters and have an effective effect at different depths.

In the study by F.A. Soriano (1995), a pronounced analgesic effect was achieved after 10 daily sessions of laser pulsed Infrared LILI therapy (904nm wavelength, 20W pulse power, 10.000Hz frequency, 200ns pulse duration) in 938 patients with joint and muscle pain – both acute, and chronic, with different localization is reported. Our experience shows that it is often enough to conduct only 1–2 "anesthetizing" sessions with the maximum frequency (10.000Hz in this case), then reduce the frequency to 80–150Hz and carry out "restorative" therapy aimed at eliminating the cause of the occurrence of pain.

In a detailed analysis of the study, one can find publications in which the analgesic effect has not been adequately demonstrated, and it is necessary to understand why this has happened. For example, after suturing 26 patients (a total of 52 healthy adults undergoing endodontic surgical treatment in a double-blind, randomized clinical trial), they were exposed to a continuous infrared LILI (809nm) of 50mW, exposure to 150 seconds. The results showed that the pain level (according to the VAS) in the group with illumination therapy was lower than in the placebo group, but statistically significant differences were observed only on the first day after the operation [Kreislner M.B., et al., 2004]. In another study, ten patients immediately after surgical treatment of the periodontium were treated by LILI with a wavelength of 780nm (35J/cm², 70mW, 20 seconds per point) and a wavelength of 635nm (35mW, 10 seconds per point, 8.8J/cm²). After 24 and 48 hours, LT was repeated at a wavelength of 635nm, the results were evaluated after three days. The decrease in the inflammatory process was definitely shown, but no analgesic effect (according to VAS) was observed [Ribeiro I.W., et al., 2008]. Both studies combine one thing – an absolutely inadequate technique of impact, the consequence of which was the lack of results. There are also more vivid examples when LILI with a wavelength of 830nm and a power density of 300mW/cm² (!) was used, while trying to simultaneously accelerate the healing of a purulent wound and anesthetising it [Lagan K.M., et al., 2001], but the parameters of the method are such that in this case the effect cannot be obtained in principle. Although, for anaesthesia many authors recommend the power of just such order – up to 300–400mW (wavelength 830nm, continuous mode) [Chow R.T., Barnsley L., 2005; Chow R.T., et al., 2006; Fikácková H., et al., 2007], but it would be quite fair in this case to raise the question of the applicability of parameters for various types of pain and its causes. Strict differentiation is necessary.

Studies, especially the earlier ones, demonstrate how important it is to properly provide laser therapy in order to obtain the desired result [Basford J.R., et al., 1990; Fernando S., et al., 1993; Lowe A.S., et al., 1997; Payer M., et al., 2005; Taube S., et al., 1990]. LILI selectively inhibits the work of nociceptive neurons, the effect is largely dependent on both their localization and the effect area (zone) [Kasai S., et al., 1996; Tsuchiya K., et al., 1994]. The lack of a positive results in a number of studies may be due largely to the incorrectly chosen zone and the technique of exposure.

However, most analytical reviews of the studies show that there is a positive effect due to the fact of not the best methodological and technical support being provided. A meta-analysis of 16 randomized controlled trials (a total of 820 patients with acute neck pain) showed that in 95% of cases laser therapy can reduce pain immediately after treatment, and the effect persists until 22 weeks after completion of treatment in patients with chronic pain [Chow R.T., et al., 2009]. A similar analysis of the literature for 2005–2007 conducted on the basis of CENTRAL, MEDLINE, CINAHL, EMBASE, AMED and Pedro without any language restrictions showed that LILI significantly reduces nonspecific pain in the back and the effect persists up to six months. [Yousefi-Nooraie R., et al., 2008].

The study of the effect LILI with a wavelength of 780–785nm (continuous mode) on pain sensations during the palpation of the masticatory and anterior temporal muscles

(the evaluation was carried out by electromyography) made it possible to understand that only large powers (more than 50–60mW) give a statistically significant reduction in pain in all palpable muscles [Venezian G.C., et al., 2010]. In the treatment of patients with MFPS and pain in the temporomandibular joint (TMJ), some researchers recommend increasing the power to 400mW (for a wavelength of 830nm) [Fikácková H. et al., 2007]. In this case, there is a certain logic, since in this spectral range the absorption is less than at a wavelength of 780–785nm.

The influence of pulsed infrared LILI locally contributes to the reduction of pain and recovery of patients with plantar fasciitis, also at a significant average power (wavelength 904nm, frequency 5000Hz, matrix of 4 LD's with a pulse power of 20W and an average power of 60mW) [Kiritsi O. et al., 2010]. Although this is absolutely not required in this case, our technique using the same pulsed Infrared lasers (904nm wavelength) comparable to the pulse power (60–80W, matrix of 8 LD's), but at a frequency of 80Hz (the average power is only about 1mW) allows to reach an almost guaranteed result after the first procedure [Builin V.A., Moskvina S.V., 2005].

Many researchers emphasize the direct relationship between the power density of LILI and the analgesic effect [Navratil L., Dylevsky I., 1997]. H. Otsuka et al. (1995), to intensify the analgesic effect in patients with Herpes zoster, recommended to pre-scan the lesion area with a HeNe laser beam (633nm, 8–9mW, continuous) 10–15 minutes, then illuminate with an AlGaAs laser (830nm, 60mW, continuous) Contact (PM 1–3W/cm²) for five minutes, over the course of 3–5 sessions. The rationale for the need for such a combined methodology is not given. H. Yamada and H. Ogawa (1995) believe that an increase in the power of an Infrared laser (830nm) to 150mW with postherpetic neuralgia makes it possible to obtain an even more pronounced analgesic effect.

When studying the reaction of the sciatic nerve of rats (changes in somatosensory evoked potentials and potentials of the action of muscles) to the effect of LILI, it is shown that for anaesthesia, the impact point, wavelength, time (no less than 120 seconds) and, necessarily, the minimum area, i.e. maximal power density [Chow R., et al., 2012].

In a meta-analysis of the possible use of laser therapy to reduce pain (VAS score), conducted by A.M. Fulop et al. (2010), according to the criteria of reliability (placebo-controlled studies), 22 publications were selected, in which a sufficiently high efficiency of LILI with a variety of parameters was clearly proved (Table 16). However, it should be noted that the power density and the exact impact technique are almost never indicated, in some studies there is not even a wavelength of the laser source. Basically, the procedures were performed daily, over the course of 8–12 days, but in some studies they were conducted for 15–18 [Brosseau L., et al., 2005; Hirschl M. et al., 2004], 20 [Gur A. et al., 2003⁽¹⁾] and even 62 [Hakgüder A. et al., 2003], which raises the question of the effectiveness of the selected parameters of the techniques in these cases. The exposure to one point is not always indicated (most often 1, 2, 3 or 5 minutes), only the total time of the procedure, which in some studies exceeded the permissible threshold of 20 minutes and was 30–40 minutes [Gur A. et al., 2003⁽¹⁾; Hirschl M. et al., 2004], which is reasonably correlated with the increased number of procedures (low

Table 16

Method parameters of reliable studies that have proven the effectiveness of the anaesthetic effect of laser illumination therapy (Fulop A.M. et al., 2010)

No.	Disease	Wavelength, nm (laser mode)	Power, mW	Exposure, min	Energy or ED	Studies/References
1	MFPS	904 (pulse)	5.4 (27W, 1000Hz, 200ns)	2 min for 4 TP	Spot area 1cm ²	Altan L. et al., 2005
2	Pain in the shoulder	904 (pulse)	20 (50W, 2000Hz, 200ns)	1	2.98J/cm ²	Bingöl U. et al., 2005
3	Osteoarthritis of the hands	860 (continuous)	30	20	3J/cm ²	Brosseau L. et al., 2005
4	Chronic pain in the neck	830 (continuous)	300	30 seconds per zone	20J/cm ²	Chow R.T. et al., 2006
5	Delayed onset muscle soreness, (DOMS)	660 and 880 (continuous)	Matrix	80 s	8J/cm ²	Douris P. et al., 2006
6	MFPS	830 (continuous)	450	2	630J	Dundar U. et al., 2007
7	Carpal tunnel syndrome	780 (continuous)	50	10	75J	Ekim A. et al., 2007
8	Dysfunction of the TMJ	830 (continuous)	400	-	10J/cm ²	Fikackova H. et al., 2007
9	FM	904 (pulse)	11.2 (20W, 2800Hz, 200ns)	3 min for 10 TP	Spot area 1cm ²	Gur A. et al., 2002
10	Gonarthrosis	904 (pulse)	20W	3 or 5	30 and 20J	Gur A. et al., 2003
11	Back pain (lumbago)	904 (pulse)	10W	3 or 5	1J/cm ²	Gur A. et al., 2003 ⁽¹⁾
12	MFPS	904 (pulse)	11.2 (20W, 2800Hz, 200ns)	3 min for 10 TP	Spot area 1cm ²	Gur A. et al., 2004
13	MFPS	780 (continuous)	10	3	5J/cm ²	Hakgüder A. et al., 2003
14	Raynaud's syndrome	685 (continuous)	20	30-40	2J/cm ²	Hirschl M. et al., 2004
15	Experimental wound	820 (continuous)	Matrix of 46 LD, power not indicated	2	8J/cm ²	Hopkins J.T. et al., 2004

Table 16 cont'd

No.	Disease	Wavelength, nm (laser mode)	Power, mW	Exposure, min	Energy or ED	Studies/References
16	Osteoarthritis of cervical vertebrae (cervical spondylosis)	830 (continuous)	50	3 minutes (15 seconds per zone)	0.9J/cm ²	Ozdemir F. et al., 2001
17	Injury of the tendon	904 (pulse)	27 and 50W	130 s	–	Ozkan N. et al., 2004
18	Tendonitis of supraspinatus	820 (continuous)	50	90 s	30J/cm ²	Saunders L., 2003
19	Lateral epicondylitis	904 (pulse)	40	30 seconds per zone	2.4J/cm ²	Stergioulas A., 2007
20	Pain after tartar removal	637 and 957 (continuous)	Matrix, power is not specified	6 min before and 10 min after the cleaning procedure	–	Takas D. et al., 2006
21	Osteoarthritis	830 (continuous)	50	1 or 2	15J (total)	Tascioglu F. et al., 2004
22	Polineuropathy	905 (pulse)	0–60	5	–	Zinman L. et al., 2004

efficacy). If we add to this to the great differences in the etiology of diseases and their wide spectrum, apart from ascertaining the fact of the very possibility of using laser therapy, it is impossible to say anything specific about the best methods of anaesthesia.

In a similar, but earlier review [Bjordal J.M., et al., 2003], only patients with chronic joint diseases were selected, which made it possible to more objectively compare the effectiveness of different methods, systematize the conclusions and propose ranges of more optimal energy parameters for them (Table 17).

Table 17

The proposed ranges of power and energy densities for the common laser in the treatment of patients with various joint diseases, depending on the technique (Bjordal J.M. et al., 2003)

Localization	Continuous infrared lasers (820, 830 and 1064nm)		Pulsed infrared laser (904nm)		Continuous red laser (633–635nm)	
	PM, mW/cm ²	Energy, J	PD, mW/cm ²	Energy, J	PD, mW/cm ²	Energy, J
Joints of the fingers and TMJ, 1 point of 1 cm ² , impact on depth to 0.2 cm	15–105	0.5–15	6–42	0.2–1.4	30–210	6–30
Knee, 3 points of 3cm ² , impact on depth to 0.4cm	30–210	6–180	12–60	1.2–84	90–500	9–2700
Cervical spine, 3 points of 3cm ² , impact on depth up to 1.2cm	50–350	11–360	24–60	0.8–56	150–500	5–150
The lumbar spine, at 3 points of 3cm ² , affects the depth to 3cm	180–500	48–480	30–210	15–105	Enough power of sufficiently safe lasers	Not applicable

Commenting on this table, the following positive points should be noted:

- the very fact of systematization;
- Separation, depending on the spectral range and mode of operation of the laser;
- separation according to methods;
- Setting the power density, rather than its absolute value.

There are also disadvantages:

- the techniques are not always the most optimal, in particular, the selected exposures;
- the depths of “penetration” indicated in the methods are far from real values;
- setting the area of exposure 3cm² is not justified;
- separation by localization is not always justified;
- indicating the energy per session is of no practical use, it is necessary to set the exposure for a single zone and the power density.

The authors of the study discuss in great detail how important it is to ensure the optimal value of the power density and to select the required area of influence, which has limitations both above and below. This is due, on the one hand, to the requirement

to increase power, and on the other hand – the choice of methodology. For example, the size of a light spot at a local exposure and on a AP is radically different.

It was concluded that in all the placebo-controlled studies, a reliable positive result was obtained (Table 18), and the differences in efficacy were due to the failure to provide optimal parameters of the procedure, as a result of a lack of understanding of the mechanisms of the analgesic effect of LILI [Bjordal J.M., et al., 2003]. In later meta-analyses, conducted with respect to LT, patients with lateral epicondylitis of the elbow joint (“tennis elbow”), J.M. Bjordal et al. (2008) and A.R. Gross et al. (2013) concluded that the effectiveness of treatment in general, and the analgesic effect of LILI in particular, is much higher when using pulsed infrared lasers (904nm) (compared to the continuous ones: 633, 820, 830 and 1064nm), whose effectiveness is generally questioned. The therapeutic properties of laser light are much higher than from injections of steroid drugs, but only under the condition of setting optimal parameters of the technique. However, as often happens, discussion of this topic in almost all analytical studies revolves around the notorious “dose”, which is doubly meaningless for pulsed lasers. Therefore, there are no precise recommendations, despite the large number of reviews.

In a similar meta-analysis, the validity of J.M. Bjordal et al. (2003) (Table 18) was proved for the optimal energy ranges. It is in these studies that the greatest efficacy of laser therapy is shown [Jang H., Lee H., 2012]. The parameters of the methods of the studies are shown in Table 19 (with the exception of those already mentioned in Tables 16 and 17), studies from other surveys have also been added [Aggarwal A., Keluskar V., 2012; Chow R.T., Barnsley L., 2005; De Andrade A.L.M. et al., 2016; Gross A.R. et al., 2013; He W.L. et al., 2013; Melis M. et al., 2012] and several other articles not included.

Even with a glance at Table 18 and 19, the almost maniacal desire is obvious, of the overwhelming majority of researchers that focus laser light literally to the point, revealing fantastic PD’s that are obtained during calculation, is striking for real, although this approach is clearly erroneous in the overwhelming majority of cases. Sometimes a high concentration of laser light is methodologically justified, but in these cases, it is completely pointless to make calculations of ED.

Many works, even reviews, do not mention the most important parameters of the method, such as exposure time and exposure localization, but almost everywhere there is “energy” or “ED”, which is absolutely uninformative and are unnecessary indicators [de Andrade A.L.M. et al., 2016]. Will we ever forget about them?

Practically all methodics are of the same type and stable, when LILI parameters do not change during the course, and this is a fundamental mistake. In the methodology of pain management, laser therapy is really effective only under the condition of variability. Apparently, many researchers do not even have a small of understanding such an obvious fact.

We have to state that despite many publications in the international press, one can draw conclusions only on the irrefutable fact of LILI’s analgesic effect, but almost nothing can be said about the parameters of effective “anaesthetic” techniques, especially in the methodology of LT.

Table 18

Parameters of LILI in the treatment of patients with various joint diseases (Bjordal J.M. et al., 2003)

Nº	Impact localization	Wavelength, nm (laser mode)	Power, mW	PM, mW/cm ²	Exposure, min (15 seconds per point)	Sessions per week	References/Studies
1	Thumb	633 (continuous)	0.9	90	1 (15 seconds per point)	9/3	Basford J.R. et al., 1987
2	Knee	904 (pulse)	0.3 (2W, 200Hz)	0.3	6	5/5	Jensen H. et al., 1987
3	Lumbar spine	904 (pulse)	0.4 (2W, 200Hz)	0.4	4	8/2	Klein R.G., Eek B.C., 1990
4	Knee	633 (continuous)	75	34	7.5 + 7.5	20/10	Stellan J. et al., 1992
		820 (continuous)	25	eleven			
5	Knee	904 (pulse)	4 (10W, 5000Hz)	57	3	6/3	Nivbrant B., Friberg S., 1992
6	Knee	830 (continuous)	25	110	1-3	9/3	Bülow P.M. et al., 1994
7	TMJ	904 (pulse)	4 (27W, 800Hz)	57	3	12/3	Gray R.J.M. et al., 1994
8	Lumbar and cervical spine	830 (continuous)	60	3000	9	1/1	Toya S. et al., 1994
9	TMJ	904 (pulse)	4 (10W, 700Hz)	57	9	9/3	Bertolucci L.E., Grey T., 1995
10	Knee	904 (pulse)	12 (25W, 2500Hz)	4	13	12/3	Gøtts S., Keyi Wand Wirzbach E., 1995
11	TMJ	830 (continuous)	100	38.887	40 seconds	4/1	Conti P.C., 1997
12	Musculoskeletal pain in the lumbosacral region	904 (pulse)	40 (20W, 10.000Hz)	40	6	10/5	Soriano F.A., Rios R., 1998
13	Musculoskeletal pain in the lumbosacral region	1064 (continuous)	1626	542	6	12/3	Basford J.R. et al., 1999
14	Cervical spine	830 (continuous)	50	50	3 (15 seconds per zone)	10/7	Ozdemir F. et al., 2001

Table 19

Parameters of LILI when exposed to joints of different locations for analgesia (Aggarwal A., Keluskar V., 2012; Chow R.T., Barnsley L., 2005; Gross A.R. et al., 2013; He W.L. et al., 2013; Jang H., Lee H., 2012; Melis M. et al., 2012)

N ^o	Impact localization (Disease)	Wavelength, nm (laser mode)	Power, mW	Size of the light spot, cm ²	PM, mW/cm ²	Exposure	Number of zones per session	References/Studies
1	Finger of the hand (rheumatoid arthritis)	780 (continuous)	70	0.06	1166*	2.57 seconds	4	Meireles S.M. et al., 2010
2	Knee (gonarthrosis)	830 (continuous)	50	0.005	10.000*	2 minutes	8	Hegedüs B. et al., 2009
3	TMJ	904 (pulse)	17	1	17	3 minutes	4	Kulekcioglu S. et al., 2003
4	TMJ	780 (continuous)	30	0.05	630*	10 seconds	3	Venancio R. de A. et al., 2005
5	TMJ	830 (continuous)	-	-	43	162 seconds	4	Cetiner S. et al., 2006
6	TMJ	633 (continuous)	30	2.4	12.5	2 minutes	-	Emshoff R. et al., 2008
7	TMJ	830 (continuous)	40	0.04	5000*	16 seconds	4	Santos T. de S. et al., 2010
8	TMJ	780 (continuous)	70	0.7	90	10 seconds	4	Mazzetto M.O. et al., 2007
9	TMJ	830 (continuous)	500	0.1	5000*	20 seconds	1	da Cunha L.A. et al., 2008
10	TMJ	780 (continuous)	70	0.04	1750*	60 seconds	2	Carrasco T.G. et al., 2008
11	TMJ	980 (continuous)	17	1	17	60 or 120 seconds	2	Lassemi E. et al., 2008
12	TMJ	980 (continuous)	1000	2-3	330-500	From 3 to 30 seconds	-	Agha M.T., 2007
13	IFAC	660 (continuous)	17	1	17	6 minutes	-	Shirani A.M. et al., 2009
		890 (pulse)	10 (10W, 1500Hz, 100ns)	1	10	10 minutes		
14	Shoulder (humeroperic periarteritis)	830 (continuous)	60	0.5	120*	30 seconds	8	Stergioulas A., 2008
15	L1 and S11-S111 (chronic lumbosacral pain)	810 (continuous)	50	0.22	226*	2 minutes	8	Djavid G.E. et al., 2007
16	Chronic lumbosacral pain	850 (continuous)	12	0.07	166*	4 minutes	-	Ay S. et al., 2010
17	TMJ	820 (continuous)	300	0.28	800*	10 seconds	-	Röhlig B.G. et al., 2011

Table 19 cont'd

N ^o	Impact localization (Disease)	Wavelength, nm (laser mode)	Power, mW	Size of the light spot, cm ²	PM, mW/cm ²	Exposure	Number of zones per session	References/Studies
18	TMJ	830 (continuous)	100	–	4J/cm ² (?)	–	–	Kato M.T. et al., 2006
19	TMJ	830 (continuous)	150	–	4200*	5–10 seconds per point, 2–4 minutes per session	–	Kobayashi M., Kubota J., 1999
20	IFAC	904 (pulse)	5 (25W, 1000Hz, 200ns)	0.2	25*	200 seconds for TP and 20 seconds for AP	4 TP and 10 AP	Ceccherelli F. et al., 1989
21	Radiculopathy	905 (pulse)	50 (100W, 5000Hz)	4	12–20	2 minutes	4–6 segmental points	Konstantinovic L.M., 2010; Konstantinovic L.M. et al., 2010
22	Sharp pain in the neck	904 (pulse)	40 (20W, 10.000Hz, 200ns)	–	–	15 seconds	1	Soriano F.A. et al., 1996
23	Diseases of the joints	904 (pulse)	24 (60W, 10.000Hz, 40ns)	1	24	175 seconds	5–9	Taverna E. et al., 1990
24	TMJ	904 (pulse)	45W (1–50Hz)	–	–	5 or 10 minutes	3	Marini I. et al., 2010
25	TMJ	820 (continuous)	60 or 300	–	21.4 and 107J/cm ² (?)	–	–	Sattayut S., Bradley P., 2012
26	Sharp pain in the neck	830 (continuous)	1000	1.5	630*	30 seconds	8	Takahashi H. et al., 2012
27	Sacrum and ilium joints	830 (continuous)	1000	1.5	630*	30 seconds	8	Ohkuni I. et al., 2011
28	Pain in the elbow, wrist and fingers	830 (continuous)	1000	1.5	630*	30 seconds	–	Okuni I. et al., 2012
29	Chronic pain of various locations	810 (continuous)	100	–	9500*	60 seconds	–	Fukuuchi A. et al., 1998

Table 19 cont'd

N ^o	Impact localization (Disease)	Wavelength, nm (laser mode)	Power, mW	Size of the light spot, cm ²	PM, mW/cm ²	Exposure	Number of zones per session	References/Studies
30	Tendinitis and MFPS	904 (pulse)	8 (10W, 4000Hz, 180ns)	-	0.5-1J/cm ² per point (?)	-	-	Lögberg-Andersson M. et al., 1997
31	Postoperative wound	830 (continuous)	40	0.08	500*	26 seconds	10	Carvalho R.L. et al., 2010
32	Cervicogenic headache	780 (continuous)	70	1	70	37.5 minutes	8	Pizzo R.C.A. et al., 2010
33	Chronic post-mutilation pain	780 (continuous)	40	-	-	10-20 minutes	-	Yonekawa N.S. et al., 2010
34	Radiculopathy caused by a herniated intervertebral disc	904 (pulse)	40 (65W, 3000Hz, 200ns)	1	40	100 seconds (optimal)	-	Jovicic M., 2010
35	TMJ	830 (continuous)	280	0.2	1400*	11	-	Dostalová T. et al., 2012
36	TMJ	780 (continuous)	70	0.04	1750*	30 seconds	-	Barretto S.R. et al., 2013

* is, of course, not the real power density, but only the product of a complicated calculation, showing that sometimes a contact technique is used in which the laser diode directly touches the surface of the area, thus ensuring the greatest possible concentration of energy on the surface.

The material presented above is almost entirely based on the data of international researchers, which does not mean there is an absence of relevant publications in Russia. There are plenty of them, however, and not only are there many more, but most importantly, it is these very works that are based on truly effective methods of pain management.

Methodological features of “laser anaesthesia”

To emphasize once again the possibility of the multidirectional nature of the LILI, depending on the methodology and a number of other reasons, let us pay attention to one important circumstance. Sometimes, such as in this case, a reverse, or “antianalgesic” effect can be observed, for example, a reduction in the duration of anaesthesia was observed when using LILI in the postoperative period due to increased local circulation due to vasodilation of the vessels and accelerated excretion of local anaesthetics [Aras M.H. et al., 2010; Carrillo J.S. et al., 1990; Clokie C. et al., 1991; Marković A., Todorović L., 2006; Røynesdal A.K. et al., 1993; Schindl A. et al., 1998; Zarković N. et al., 1989]. This should be taken into account when implementing correlated multiple (combined) laser therapy options.

In most methods of pain management, pulsed lasers are more preferable, which allow for a much wider range of varying the energy parameters of LILI by changing frequency, which is extremely necessary and is the main feature of the laser therapy methodology in this field of medicine. We have already spoken above about the stability of the exposure, which is practically constant with respect to other parameters of the technique, but the power can be changed in very narrow limits, and the frequency of pulsed lasers is from 80 to 10.000Hz (for the Lasmik series), i.e., almost by 125 times!

We remind you that the maximum power (power density) at a frequency of 10.000 Hz (when the average power and energy for pulsed lasers are also maximal) often provides anaesthesia, but such regimes cannot always be used throughout the treatment course, and are sometimes even excluded. For example, analgesia in certain joint diseases is generally effective only when using pulsed infrared LILI (904nm, power 20W), frequency 10.000Hz for acute pain and 80–150Hz for chronic pain [Gham-sari S.M. et al., 1995].

We give other examples of frequency variation for pulsed lasers (we mean the matrix pulsed laser emitting heads of the type ML-904-80 and ML-635-40). With lumbago, the first 1–2 procedures are carried out with a maximum frequency (no less than 3000Hz), whereas subsequently, no less than 10–12 sessions only with a frequency of 80–150Hz, i.e. with a minimum average power, providing restoration of disturbed physiological processes. A similar situation is observed when blocking the pain syndrome in the case of acute pancreatitis with a slight variation. If in the previous case, the effect is carried out on one zone (maximal soreness) for five minutes, then for pancreatitis – for 1.5 minutes for three areas in the direction from the head of the pancreas to the tail (the total time of the procedure is five minutes). Also, one or two of the first procedures can be carried out with the maximum frequency, exclusively for effective analgesia, but

then, from the third procedure, throughout the course – only a frequency of 80–150Hz and not higher. If we are talking about the problem of pain itself, then in the above examples it is quickly resolved in the first 1–2 sessions, and then follows the treatment of laser therapy aimed at eliminating the cause itself and minimizing the probability of its occurrence in the future.

The choice of the wavelength of LILI is more complicated, for example, it is unclear what is more effective: pulsed Infrared lasers (904nm), the most common, or red spectrum (635nm), whose action for the method of anaesthesia has not been studied so far. Additional comparative studies are required to answer this question.

The LT methodology implies different variants of both local and systemic effects, one of which is the illumination of a stellate ganglion. It is known that this blockade is carried out when it wants to achieve maximum regional vasodilation in the region of the head, neck and upper limb, especially with acute spasm of vessels in the basin of the vertebral artery, as well as the common and internal carotid artery. Many authors, with the appropriate localization and pathology, recommend the effect on the projection of the stellate node with continuous Infrared LILI, in order to suppress excessive sympathetic activity that aggravates the pain, and call this technique a laser blockade [Hashimoto T. et al., 1997; Kemmotsu O., 1997, 1998; Murakami F. et al., 1993; Otsuka H. et al., 1992]. S. Tamagawa (1996) emphasizes the need for a complex impact of LILI topically on the stellate ganglion alongside taking antidepressants. In cervicobrachialgia with vegetative-vascular manifestations, laser illumination is performed on segmental zones (up to 6) as well as on the localization of pain and stellate ganglia, along the course of the neurovascular bundle on the shoulder and forearm, fingertips [Ulashchik VS et al., 2003⁽¹⁾]. It is repeated once again, pulsed lasers in this technique are preferable.

There are numerous reviews on “laser pain management” (Chow R.T., Barnsley L., 2005; Chow R. et al., 2011; Chow R.T., Armati P.J., 2016; Chow R.T. et al., 2009; Gross A.R. et al., 2013; Yousefi-Nooraie R. et al., 2008], but there are publications in which this problem not considered in view of one of the most important circumstances – the study of what type of pain, primary or secondary, was carried out in the analysed works. This is exclusively, fundamentally important, since the absence of such differentiation initially leads to errors in the choice of the laser exposure technique.

Although almost all the methods of laser therapy presented in the previous chapter are used to achieve the goal, but it is possible to single out a special method, which is characteristic only of the pain syndrome, of muscle pain, most often with FM and MFPS. This effect on trigger points (TP), a technique that is also sometimes called a laser blockade in specialized studies, and its components are very different from those of standard local coverage. The technique is often used as the main one, but it should not be forgotten that only expanding the “assortment” of laser therapy methods contributes to the maximum increase in the effectiveness of treatment. It must also be remembered that the safety and efficacy of any method of treatment, including laser therapy, is provided only if it is applied correctly.

There are several common methods of laser therapy (methods of laser illumination) [Moskvin S.V., 2016; Moskvin S.V., 2017]:

- externally topically;
 - in the projection of internal organs;
 - on immunocompetent organs;
 - on large blood vessels: intravenous laser blood illumination (ILBI) and non-invasive laser blood illumination (NLBI);
 - paravertebrally;
 - at the acupuncture points (AP);
 - on the projection of internal organs;
 - Trigger, or painful (trigger, tender), points (TP) and painful zones (PZ).
- There are fairly strict rules for these methods [Laser therapy ..., 2015]:

- limitation of exposure time;
- determining the use of the optimal power density (PD) for the selected wavelength of LILI;
- It is preferable to use pulse mode, which is especially important for pain management.

Unfortunately, in most international scientific publications, when using laser therapy as the main method for treating patients with FM and with other pain syndromes, the parameters of the methods are far from effective, so the results are often not impressive. Continuous lasers are used, and in the most inefficient spectral range (800–850nm), which does not add to the attractiveness of international methods, if we talk about the effectiveness of treatment. Fortunately, in Russia, such lasers, as they are practically useless, were abandoned in the early 1990's.

As well as the wide choice of medications prescribed depending on the type of pain, the methods of laser therapeutic treatment are also extremely diverse. The choice of the right basic scheme and tactics of further variation by the parameters of the laser therapy technique determines the success of treatment in this case quite radically: either an exclusively pronounced effect is achieved or it will be absent altogether. In special techniques in the relevant literature, one can find recommendations for the elimination of the pain syndrome in each specific case, but there are general principles that unite them.

Some specialists completely doubt the efficacy of physiotherapy for pain relief: "Today, there is insufficient evidence to support the use of conservative non-drug therapies (for example, physiotherapy, physical exercises, PENS). However, considering the relative safety of these methods, in the absence of contraindications, their use should not be ruled out" [Danilov A.B., Davydov O.S., 2008].

In fact, the situation is fundamentally different.

Firstly, there are thousands of reliable model and clinical studies, as well as many years of extremely successful experience in the use of physio- and laser therapy worldwide. This can be seen even from our far from completed list of literary sources written about this issue. One can also refer to numerous international practical guidelines [Boswell M.V., Cole B.E., 2006; Fishman S.M. et al., 2009], because we are so fond of appealing to the opinion of the Anglo-Saxons on any issue. If someone does not know about the highest, sometimes non-alternative effectiveness of laser therapy in the management of pain, or does not want to know, then this does all kinds of negative

things. Most likely, such a statement is due to a personal commercial interest in promoting without an alternative to some other method of treatment.

Secondly, the big question is what is the treatment in the true sense of the meaning of this word (the authors of the quotation cited above even identified it), and that is only imitation. For many specialists and patients, the answer to this question is not in favour of pharmacological drugs. In our opinion, the best treatment option is the complex approach, with both a pathogenetically justified pharmaceutical preparations and physiotherapy, in which laser methods are involved and occupy far from last place. Other experts agree with our point of view [Shiman A.G., et al., 2014; Shostak N.A., Pravdyuk N.G., 2012].

According to international colleagues, the effectiveness of analgesia after a course of laser therapy can reach 60–70% with rheumatoid arthritis, with chronic muscular pain and post-herpetic neuralgia 70–80% [Moore K.C., 2006]. In fact, with the right choice of the technique, a positive result can be obtained in almost 100% of cases, but for this it is necessary to know and follow the basic rules for the application of laser pain management techniques using a single option – the error is fraught with LT discrediting. Here are the main approaches.

1. Pain – the concept of a clinically and pathogenetically complex and heterogeneous, respectively, methodological approaches to the design of therapeutic regimens (techniques) of laser therapy are distinguished by an exceptional variety.
2. It is necessary to initially classify the pain syndrome as a neuropathic (primary) or nociceptive (secondary). This is the main thing that determines the methodology of laser therapy and the choice of treatment tactics in general.
3. The use of correlated and combined methods, including both different methods of laser exposure, as well as other methods of treatment (physiotherapeutic, exercise therapy, pharmacological, surgical, etc.) is required to be maximally active.
4. Among the methods of laser therapy the main ones can be identified: the impact on TP and lesions, as well as NLBI or ILBI; additionally: the effects on immunocompetent organs, paravertebral and laser acupuncture.
5. High, even marginal capacities, sometimes with minimal exposure areas (for the formation of high PD) a guarantee of an anaesthetic effect in many cases, but not always and for a short time.
6. Pulsed low-intensity laser light of infrared (904nm) and red (635nm) ranges is indispensable in anaesthesia programs with local exposure directly to the lesion, the projection of internal organs and TP, and continuous (sometimes modulated) laser light is used only for acupuncture and ILBI.
7. For pulsed therapeutic lasers (laser diodes with a pulse duration of 100–150ns and pulsed power from 10 to 100W are most often used), the average power is proportional to the repetition rate of pulses. The maximum power is achieved at a frequency of 10.000Hz, which is the maximum permissible.
8. The minimum frequency with a pulse duration of 100–150ns and a pulsed power from 10 to 100 W is 80Hz – at a lower average power of biologically significant effects is no longer observed.

9. There are four main approaches to the frequency variation for pulsed lasers (which is identical to a change in the average power for this mode) for the purpose of pain management:
 - local impact on the lesion, sometimes on the TP: the first 1–2 sessions are high (but not more than 10.000Hz), followed by a decrease to a minimum value (80Hz) during the remaining sessions of the therapeutic course, consisting, as a rule, from 10–12 daily procedures;
 - at local impact on the lesion: frequency is the highest (10.000 Hz) during the entire course, as a rule, these methods use the highest power density of LILI;
 - at local impact on the lesion: frequency 80Hz without variations from the first procedure the entire course, sometimes 2–3 procedures is enough;
 - when exposed to TP and peripheral nerve fibres: variation in frequency throughout the course, from the minimum level (80Hz) to the maximum value (3000–10.000Hz) and back.

This approach (change in frequency for pulsed lasers) is identical to the variation in power for continuous lasers, but the dynamic range of possible changes for them is extremely small, in addition, the continuous regime is much less effective than pulsed, when it comes to laser therapy. The change in power from procedure to procedure, the use of various types of modulation, including multifrequency, partially solve the problem, but it is better and easier to use pulsed lasers.

Features of joint-muscle pain. Fibromyalgia and myofascial pain syndrome

As was shown in the previous chapter, all the existing varieties of the characteristics of pain are largely due to localization and the source that caused it. For pain management, an informed selection of appropriate drugs and effective treatment methods, particularly laser therapy that is based fundamentally important pathophysiological mechanisms to distinguish its two versions: neuropathic (nonspecific primary) and nociceptive (specific, secondary) pain [Wayne A.M. et al., 1999; Kochetkov A.V. et al., 2012].

Sufficiently distributed such kind of pain, such as muscle or joint and muscle, one prominent example of which is fibromyalgia (FM) – rheumatic disease of unknown etiology, characterized by generalized muscle weakness (feeling of fatigue) and tenderness to palpation typical parts of the body, denoted by some authors as the tender points [Gür A. et al., 2002], others – trigger points [Ge H.Y, et al., 2011].

According to available data, FM affects up to 5% of patients in general practice, approximately 2–4% in the general population and up to 15% in rheumatological practice in all ethnic groups and cultures. Can be observed at any age, but most often in the period from 25 to 45 years, estimated as the most able-bodied. Most often the disease begins in the third decade of life, and is diagnosed, usually after 6–10 years after its debut, when patients notice a loss of efficiency and significant clinical signs.

The disease is mainly women, the ratio of women and men varies between 8–10:1 [Gogoleva E.F., 2001; Suleymanova G.P. et al., 2011; Breivik H., 2006; Muller W., 1991].

Population studies have shown that professional activities which are at risk include office workers (24%), health professionals (14%), educators (13%) and the unemployed (10%). According to studies, patients with FM bind their disease with prolonged operation of the computer (37%) standing for a long time (37%), sitting in the same position for a long time (27%), constant stress (21%), severe physical exertion (19%) and with constantly repeated monotonous movements (18%) [Wayne A.M. et al., 1999; Suleimanova G.P., 2005; Blotman F., Branco J., 2007; Muller W., 1991].

Other factors that may trigger the onset of the disease are a high moisture, low barometric pressure, surgery, neck injury (40%) and the lumbar spine (19–31%) [Suleimanova G.P., et al., 2011; Tabeeva G.R. et al., 2000].

It is believed that the only specific phenomenon of FM is the presence of TP, originally used as the term tender points [Freundlich B. et al., 1990], and trigger points for myofascial pain syndrome (MFPS) [Travell J.G., Simons D.G., 1983], emphasizing the differences in the pathogenesis of the diseases themselves and in local painful areas [Moskvin S.V., 2016; Bennett R.M., Goldenberg D.L., 2011]. However, at present the approach has changed, there is no such fundamental division.

The presence of characteristic morbidity in certain zones (points) on the body of patients with FM was noted long ago, and in 1972 H. Smythe suggested using this fact as the main criterion for diagnosing the disease, although the patients themselves may not even know about such features. In the following, many authors pointed to the importance of identifying specific sensitive points in the diagnosis of FM. TP have the characteristic features: to cause pain, enough effort; at palpation it is possible to receive the same pain which in patients arises spontaneously; Painful points are located strictly in certain places, i.e., there is a specific map of their location [Wayne A.M. et al., 1999], in Fig. 14 shows the main ones:

- occipital region – attachment site m. Suboccipitalis;
- the neck area – the front sections of the spaces between the transverse processes at the level of CV and CVII;
- trapezius muscle – middle of upper margin of trapezius;
- supraspinatus – the place of origin m. Supraspinatus;
- sterno-rib joint at the level of the second rib;
- lateral epicondyle of the shoulder – 2cm distal;
- gluteal region – the upper outer quadrant of the buttock along the anterior margin of the muscle;
- in the medial fat cushion in the region of the knee joint.

The maximum number of TP is unknown, but women have more than men by several times, and their pain thresholds are lower compared to men, and FM patients have lower pain thresholds not only in TP zones, but also outside them. The number of TP and pain sensations correlate with the severity of the main clinical symptoms [Wayne A.M. et al., 1999].

In recent years, the situation has changed fundamentally. Most specialists tend to the fact that the “points” defined at the Moscow International AIDS Clinic are virtually

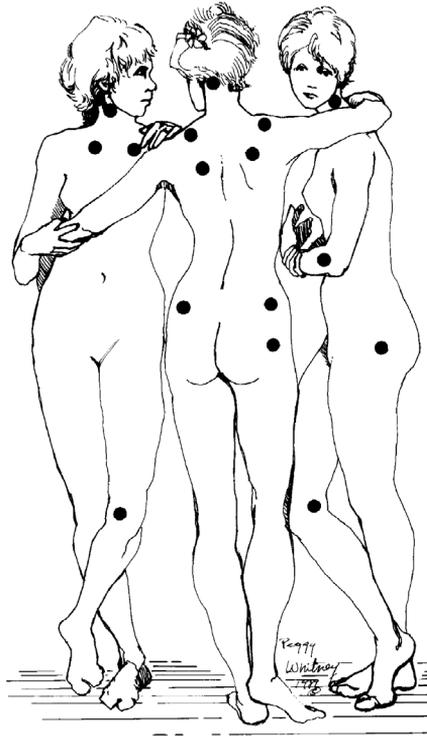


Fig. 14. Major TP's characteristic of fibromyalgia

impossible to distinguish clinically or pathophysiologically from those characteristic of FM, and the diseases themselves represent stages in a single process of chronic muscle pain [Malykhin M.Y., Vasilenko A.M., 2017]. Therefore, it is logical to combine two variants of points and briefly call them “TP”, especially since the initial letters of word combinations are the same.

Indeed, there are differences in the clinical manifestations of FM and MFPS, the main of which are gender, in the prevalence and localization, however, observations of these patients demonstrate the commonality of most clinical manifestations. In this sense, the concept of FM seems to be broader and includes also a multitude of algic, psychic, vegetative and other manifestations [Wayne A.M., et al., 1999].

In favour of this assessment of clinical picture, the fact of the correspondence of many acupuncture points (AP) to the pain zones, characteristic for both FM and MFPS, also speaks. According to some studies, there is a stable correlation between the location on the body of TP and classical AP: 238 of 255 TP's (93.3%) have an anatomical connection with AP, including 79.5% similar pain symptoms. In this case, TP is considered as a circle with a radius of about 2cm, and not a point in the direct meaning of the word [Dorsher P.T., 2006, 2009; Dorsher P.T., Fleckenstein J., 2008].

The actual TP still cause active disputes in various aspects. Can it be repeatedly determined whether they have objective evaluation criteria, such as, for example,

spontaneous electromyographic activity or specific inflammation, can they be visualized using ultrasound techniques? Is fibromyalgia a syndrome of multiple TP or is it a focal muscular pain with manifestation of central excitation? Opinions on this score are directly opposed [Bennett R.M., Goldenberg D.L., 2011].

In our opinion, the most important thing is that the TP (*tender points* or *trigger points*) is the result of the nonspecific response of the central nervous system (CNS) in its interaction with the autonomic nervous system (ANS), manifested in both FM and MFPS, i.e., pain arising in TP is neuropathic (nonspecific, primary), which is the reason for the recommended integrated approach to solving the problem of management of the pain syndrome in FM.

Sometimes quite typical TP are mistakenly associated with any local painful zone (PZ), when the pain is caused by a pathological process (trauma, inflammation, etc.) and has a nociceptive nature. Pathophysiological differences in the causes of pain of two types are caused by fundamentally different approaches to managing it. On the other hand, it is rather difficult to detect them, because there are no reliable objective methods of differentiation, and there is probably confusion of the mechanisms of the onset of pain. This creates additional difficulties, including in the correct interpretation and systematization of scientific data.

The main thing for understanding the essence of FM is, in fact, the question of the nature of the pain syndrome. In this case both arrangements are discussed with the presence of pain nociceptive receptor deficiency, and neuropathic pain, which is based on the concept of central sensitization as reflection disturbances physiological process that results in a reduced tolerance to pain and hyperalgesia [Yunus M., 1992].

D.G. Simone et al. (2005) pointed out that about half of the observed patients with chronic myofascial pain had a deficiency in vitamins (especially B1, B6, B12, C and folic acid) and minerals (calcium, potassium, iron and magnesium). But most likely, this is a secondary result of the development of the disease, and not its cause.

Considering the data of numerous studies, the hypothesis of the pathogenesis of the disease, which links the neurochemical imbalance with the disturbance of the painful reception, looks the most likely. It is based on the data obtained in recent years on the reduction of the level of serotonin in the peripheral and, probably the central structures of the nervous system of patients with fibromyalgia. Similar results were obtained with conditions similar to fibromyalgia – migraine, irritable bowel syndrome, mental disorders. Serotonin plays an important role in the process of deep sleep, central and peripheral mechanisms of pain. In favour of the hypothesis of central serotonin deficiency may serve as evidence of declining transportation of its predecessor – tryptophan and reducing its metabolite 5-hydroxyindole acetic acid in the blood plasma of patients with fibromyalgia [Suleymanova G.P., et al., 2011; Tabeeva G.R., et al., 2000; Bennett R.M., 2004; Blotman F., Branco J., 2007].

The role of various neurotransmitters in the pathogenesis of FM are simultaneously involved in modulating pain mechanisms and in the regulation of sleep (norepinephrine, dopamine, histamine, GABA, and others.) [Russel I.J., 1996]. These neurotransmitters are also considered in the case of depression, i.e., these pathological conditions can be considered as a result of the interaction of a complex of neurochemical factors, possibly

having a pre-positional character. The idea of “multichemical hypersensitivity” in FM explains the high susceptibility to exogenous and endogenous factors, as well as the intolerance to pharmacological drugs, especially in high doses. From such positions, the fact of high comorbidity of FM with a number of clinical phenomena becomes understandable.

The connection with depression and stress allows one to assume the psychosomatic character of the disease and to put forward the concept of “psychogenic rheumatism” [Muller W., 1991]. There are reports that an inadequate response to cope with stress increases the latent readiness of the connective tissue to the inflammatory process, thereby creating favourable conditions for allergy and autoimmune processes inherent in chronic diseases. Therefore, non-adaptive behaviours associated with frustration contribute to the development of the phenomenon of neurogenic inflammation. It is understood that, in the case of stress in the region of vegetatively sensitive axons terminating in the main substance of the connective tissue, inflammatory mediators are released. Inflammation arising here is re-modelled by fibroblasts using collagen type I. The collagen cuff around the terminal vegetative and sensory axons, which can be observed at the ultrastructural level only deliver the struck axons information that decodes brain as pain. The resulting positive feedback contributes to the appearance of collagen cuffs in neighbouring axons. The spread of this process leads to FM, which is anamnistically always associated with unresolved stress reactions [Gogoleva E.F., 2001].

There is another point of view: the disease is considered as a variant of somatised depression. The generality of such clinical symptoms of fibromyalgia and depression are sleep disorders, anxiety disorders, tension headaches, fatigue, irritable bowel syndrome and the apparent therapeutic role of tricyclic antidepressants in all these states are noteworthy, which, in the opinion of some authors, can serve as evidence of the presence of a common biochemical basis for these conditions. However, doses of antidepressants in patients with fibromyalgia are much lower, and the response is much faster than in patients with depression, while there is data on the absence of psychopathic disorders in patients in the first six months of the disease, whereas if the disease is more than two years old, it was revealed that in more than 2/3 patients [Suleimanova G.P. et al., 2011; Tabeeva G.R. et al., 2000]. Thus, there is no unequivocal view of depression in studies, whether it is the cause or the consequence of fibromyalgia.

A number of reports provide data on high electroencephalographic alpha activity in deep sleep in patients with symptoms of fibromyalgia. Disintegration of delta-wave sleep by frequent intrusions of alpha activity significantly reduces the duration of stage IV of sleep, which is responsible for calm, refreshing and restoring sleep [Tabeeva G.R. et al., 2000; Blotman F., Branco J., 2007; Muller W., 1991].

A significant reduction in the level of somatomedin C in patients with fibromyalgia in comparison with healthy individuals was demonstrated (Bennett R.M., 2004). Somatomedin C is produced by the liver in response to the pulsating secretion of the growth hormone, it is the main mediator of its anabolic action and has a significant effect on muscle homeostasis. Stimulation of its products through the exogenous administration of growth hormone affects a lot of the muscle mass and muscle function in middle-

aged and elderly people. Approximately 80% of the growth hormone is produced in stage IV of sleep. Its secretion may be disrupted in patients with an alpha-delta sleep anomaly. It is possible that deep sleep is useful as an important physical restorative function, presumably modulated by somatostatin, which is released almost exclusively during stage IV of sleep. A similar opinion is held by N. Moldofsky et al. (1975), who were able to cause symptoms of fibromyalgia in healthy volunteers by depriving them of deep sleep (except for those who were engaged in physical exercises) [Suleimanova G.P., et al., 2011].

Interestingly, it is the idea that disturbed sleep can affect the work of the neuroendocrine system. A significant decrease in the secretion of thyroid hormones in response to the intravenous administration of thyrotropin-releasing hormone with an increase in prolactin secretion is described, which, according to the authors, indicates the development of hypothyroidism in fibromyalgia [Neeck G., Riedel W., 1992].

According to international authors, the incidence of major clinical symptoms in patients with fibromyalgia is as follows: widespread pain – 97.6% of cases; Sensitivity in the TP – 90.1%; Fatigue – 81.4%; Morning stiffness – 77.0%; Sleep disturbance – 74.6%; Paraesthesia – 62.8%; Headache – 52.8%; Anxiety – 47.8%; Dysmenorrhea in the anamnesis – 40.6%; “Dry” symptoms – 35.8% [Neeck G., Riedel W., 1992]. Among the other functional pain syndromes specific for fibromyalgia, first of all, migraines (22%), cardialgia (17%) and abdomyalgia (12%) are distinguished [Suleimanova G.P. et al., 2011].

Sleep disturbance in patients with fibromyalgia is considered by a number of researchers as one of the obligatory signs, which is manifested by a difficult process of falling asleep, intermittent sleep, lack of a sense of recovery from sleep, and an increase in the existing symptoms after a period of insomnia. Sleep disturbance in 75% of cases is combined with pain, asthenia and morning stiffness, irritability, high level of anxiety and inertness [Blotman F., Branco J., 2007].

The diagnostic criteria of FM do not include psycho-vegetative and psychological disorders, nevertheless their prevalence in fibromyalgia remains high [Blotman F., Branco J., 2007], 2/3 of patients with fibromyalgia suffer from various psychological disorders [Sakhnov R.A., et al., 2009; Suleymanova G.P., et al., 2011; Gogoleva E.F., 2001; Abeles A.M. et al., 2007], panic attacks (59%), hyperventilation syndrome (56%), irritable bowel syndrome (53%), heart rhythm disorders (42%), dysmenorrhea (40.6%), Raynaud's syndrome (12%, 8%), syncopal conditions (21%) and irritable bladder syndrome (14%) [Suleimanova G.P. et al., 2011].

Personality disorders are diagnosed in this disease in 63.8% of cases, depressive disorders in 80% (in 12% of the population), anxiety disorders – in 63.8% (of the population – 16%) [Sakhov R.A., et al., 2009; Tabeeva G.R. et al., 2000; Blotman F., Branco J., 2007]. There is an opinion that asthenoneurotic syndrome is one of the leading in the clinical picture of fibromyalgia, and various manifestations of this syndrome are observed in almost every patient [Suleimanova G.P., et al., 2011].

Many psychological phenomena of fibromyalgia are a consequence of chronic pain. What is notable is the fact that as the pain intensifies, psychological factors become leading in the clinical picture of fibromyalgia, which, in turn, contributes to the ge-

neralization of the process [Suleimanova G.P. et al., 2011]. As a result, the so-called vicious circle is formed, which can be broken only gradually reducing the level of pain and its dependence on the influence of external factors.

Neurological complaints are varied and can change. This is the difficulty of concentration, loss of orientation, dizziness and imbalance, some impairment of visual perception. American patients call these symptoms “fibromyalgic fog” (*fibro fog*). A neurological disorder known as “restless legs syndrome” (*RLS*) can develop if the patient has an irresistible desire to change the position of their legs, especially if the patient is lying down (more than 30%). Periodic movements of limbs in a dream are also observed (*PLMS – periodic limb movements during sleep*). Characteristic of paraesthesia – a decrease in sensitivity, especially in the extremities, a burning sensation and tingling sensations. Possible hypersensitivity to light, noise, smells. Some patients complain of increased sensitivity of the extremities to the cold (Raynaud’s phenomenon) [Suleimanova G.P., et al., 2010].

M.B. Yunus (2015), the author of some of the first criteria for diagnosing FM, developed the concept of *DSS – Dysregulation Spectrum Syndrome*. This is a set of similar conditions that have common clinical characteristics and similar pathophysiological mechanisms. In addition to fibromyalgia, this family includes eight other conditions: *chronic fatigue syndrome* (CFS), *irritable bowel syndrome* (IBS), migraine headaches, primary dysmenorrhea, periodic limb movements during sleep, Restless leg syndrome (RLS), temporomandibular joint pain syndrome, and myofascial pain syndrome.

It is believed that members of the DSS family have the following common characteristics: 1) occur in the same population groups; 2) have common symptoms (pain, fatigue, sleep disorders, are more common in women, etc.); 3) have an increased sensitivity to pain (allodynia); 4) pathology in the classical medical sense is not found (inflammation, tissue damage, etc.); 5) have the same prevalence of psychological complaints (anxiety, depression, stress); 6) probably have a genetic basis; 7) can be explained on the basis of dysfunction of the neuroendocrine system (violation of the levels of neurotransmitters and hormones of various endocrine glands); 8) patients with these diseases benefit from systemic therapy [Suleimanova G.P., et al., 2011; Yunus M.B., 2015].

In Russian specialized medical literature, the conditions characteristic for FM were also earlier denoted by the terms “local muscle hypertonus”, “neurohisteofibrosis”, “MFPS”, etc. It has now been established that the onset of FM is not directly related to degenerative diseases of the spine (dorsopathies). However, it can also form alongside them, complicating the course of the disease [Kochetkov A.V., et al., 2012]. Nevertheless, the involvement of the spinal cord in the formation of characteristic TP of the corresponding localization is undoubted.

Of considerable interest is the model of the formation of the MFPS, associated with dorsopathy, proposed by A.A. Liev et al. (1996), according to which prolonged nociceptive impulses from myofascial structures result in sensitization of specific nociceptive neurons of the posterior horns of the spinal cord. Due to these changes, the nociceptive flow to the supraspinal structures significantly increases, which leads to an increase in the excitability of the supraspinal neurons, for example, the giant cell nuc-

leus of the reticular formation, and to facilitate nociceptive transmission [A.A. Liev., et al., 2009]. Central neuroproliferative changes can also affect motor neurons at both the supraspinal level and the segmental, leading to an increase in both muscle activity and muscle tension.

Proceeding from such a conception of the mechanisms of formation of the MFPS, one of the main principles of its reduction is the suppression of impulse activity of painful conductors at the periphery, the hyperactivity of nociceptive neurons and the generators of pathologically intensified excitation formed by them at the segmental and suprasedgmental levels, which is realized through the effect on TP, the best variant of which is precisely laser illumination.

In the pathological process with FM, any muscle or group of muscles can be involved. Pain syndrome is very prevalent due to the variety of factors causing its development, including things such as anomalies of the musculoskeletal skeleton, postural overstrain of muscles in non-physiological positions, direct compression of muscles, stressful situations and diseases of internal organs and joints. In principle, almost any somatic pathology can be accompanied by a nonspecific pain syndrome characteristic of FM, which allows one to treat the disease quite often as a nonspecific phenomenon accompanying a variety of pathological and borderline states [Bennett R.M., Jacobsen S., 1994].

The involvement of nociceptive peripheral afferent nerve fibres in the pathogenesis of both FM and MFPS is confirmed by an increase in the content of substance P in muscle tissue [De Stefano R. et al., 2000].

The studies demonstrate numerous and many-sided changes in muscle tissue, from microcirculation and hypoxia disturbance to histophysiological disturbances, which initially represent mucoid swelling (myxomatous swelling of the main substance and collagen fibres), which changes over time into fibrinoid changes (the composition of isoforms of contractile and Regulatory proteins of muscle tissue with the formation of autoantigens) [Bennett R.M., 1995; Bennett R.M., Jacobsen S., 1994]. This sequence of histochemical evolution allows us to explain:

- Numerous clinical observations suggesting that the trigger point initially manifests itself in the form of a neuromuscular dysfunction and only with the further development of the pathological process can lead to dystrophic changes;
- ambiguity of information about the structure of TP, subjected to histological examination by different authors.

However, despite conducting in-depth studies in this field, the diagnosis of the disease is still difficult, since the doctor has to rely on the patient's medical history and clinical data, and most of the conventional laboratory, immunological and biochemical tests do not have a significant diagnostic value. The only laboratory method of diagnosis to date is the reduction in serotonin levels in the serum of patients with fibromyalgia.

Over a long period of observation, specialists came to the unequivocal conclusion that the treatment of patients with FM should be individual and require a holistic approach; they need time, empathy and the interaction with other professionals. Ensuring the effective management of these patients is often a real test of the professionalism of the physician [Bennett R., 2016].

Because of the lack of clear ideas about the etiology and pathogenesis of fibromyalgia, therapy is symptomatic and directed against the leading symptoms: pain, fatigue, sleep disorders and mental disorders.

One thing is certain: before the treatment begins, it is necessary to confirm the diagnosis. The long-term, sometimes stunted clinical picture, insufficient number of epidemiological studies, insufficient knowledge of doctors about this syndrome leads to the fact that patients go from doctor to doctor. Comments of the type: “You have nothing”, “You’re a hypochondriac”, “You’re pretending”, “This is hysteria” is well known to patients with fibromyalgia [Blotman F. et al., 2005; Nettleton S. et al., 2005; Rooks D.S., 2007].

In addition, the gradual onset of the disease with a slow increase in pain and fatigue for many years leads to late seeking medical care and delayed treatment.

Treatment, like diagnosis, is a complex task. It is necessary to begin with an explanation that this disease is not life-threatening, and explaining the possibility of improving, establishing a trusting relationship between the patient and the doctor; patients are given recommendations upon the regime and behaviour; if possible, the disease-provoking factors are eliminated. Fibromyalgia is a chronic disease with persistent recurrent course, and active participation of the patient in the process of treatment, strict adherence to all medical recommendations can lead to a significant reduction in the patient’s suffering [Grekhov R.A., et al., 2009].

The facts presented above allow us to confidently consider the emergence of fibromyalgia and TP as a response of the segmentary CNS apparatus to the fixation of “local” NDG in one of the neurodynamic states. Being a compensatory-adaptive reaction at the initial stage, this shift ultimately acquires the features of a pathological (supporting the fixation of the NDG imbalance) process in the future (more about these processes – in the chapter “Primary and secondary mechanisms ...”). Hence it is obvious that there cannot be a methodologically unified approach to the treatment of patients with the pain syndrome of this etiology. The idea that the CNS is more or less involved in the pathogenesis of any pain, described as a phenomenon of central sensitization, also acquires additional meaning [Danilov A.B., Kurganova Y.M., 2012; Woolf C.J., 1983].

Approaches to the treatment of patients with FM should be strictly individual. A qualified clinical evaluation of the main symptoms is required: mental disorders, the severity of the pain syndrome, the presence of sensitive points, etc. It is advisable to use the entire complex of therapeutic measures aimed at different links in the pathogenesis of the disease. Since the leading symptom of the disease is to diffuse and localise pain, the intensity of which can reach such a level that patients sometimes undergo various and sometimes repeated surgical interventions, the main attention of clinicians is aimed at finding analgesic methods of treatment. However, none of the currently known drugs completely relieve pain and other clinical manifestations of fibromyalgia [Suleimanova G.P., et al., 2011]. In addition, long-term use of analgesics, sedatives and non-steroidal anti-inflammatory drugs (NSAID’s) leads to the development of side effects, aggravating the severity of the condition of patients [Bochkova I.A., 1998].

Given the pathogenetic aspects of fibromyalgia, a significant role in the emergence, development and maintenance of its clinical manifestations is attributed to depression. Even “mild” depression can significantly change the function of neurotransmitter mechanisms, affecting sleep and pain perception and providing the conditions for the onset of fibromyalgia. On the other hand, chronic pain and prolonged physical inactivity can lead to depression. Untreated depression supports and aggravates the general symptoms of fibromyalgia, so the use of antidepressants is justified in both cases [Tabeeva G.R. et al., 2000].

A positive aspect is the analgesic effect of antidepressants, which was seen and used from the very beginning in clinical practice. Later antidepressants began to be used for the treatment of chronic pain, and their positive effect is estimated as “an increase in the pain threshold”, “depersonalization pain” interrupting the vicious circle of “pain – depression – anxiety – pain” [Suleymanova G.P., et al., 2011; Tabeeva G.R., et al., 2000].

There are the following subgroups of antidepressants: MAO inhibitors and mono-, bi-, tri- and tetracyclic antidepressants. It is established that there are currently antidepressant drugs in use exerting their effect by increasing the effect of the neurotransmitter receptor and thereby enhancing the postsynaptic response in two ways: MAO inhibitors inactivate the enzyme that causes deamination of monoamines, and tricyclic antidepressants block the “re-uptake” of neurotransmitter monoamines presynaptic nerve endings, resulting in their accumulation in the synaptic cleft and the activation of the synaptic transmission.

Great importance is attached to the activation of serotonergic transmission. Tricyclic antidepressants simultaneously inhibit the neuronal uptake of various neurotransmitter amines (noradrenaline, dopamine, serotonin). However, there are a group of antidepressants that selectively inhibit relative to capture various monoamines (fluoxetine, fluvoxamine, paroxetine, sertraline).

The effectiveness of antidepressants in the treatment of patients with FM with such clinical manifestations as pain, fatigue, sleep disorders, psycho-vegetative disorders, confirmed by a number of controlled studies [Suleymanova G.P. et al., 2011], whose data sufficiently indicated the need to prescribe smaller doses of antidepressants to obtain a therapeutic effect in patients with FM than with depression, and a more persistent therapeutic effect is noted under the condition of their long-term constant intake.

The effectiveness of tricyclic antidepressants was also noted when combined with muscle relaxants, which also have activity against pain syndromes of other localization (e.g., back pain, tension headaches), often associated with fibromyalgia.

Benzodiazepine derivatives have not been widely used in the treatment of fibromyalgia for a number of reasons: they aggravate the disturbance of stage IV of sleep, have undesirable side effects in the form of drowsiness, depression, impaired coordination, memory, muscle weakness and form a dependence.

The purpose of nonsteroidal anti-inflammatory drugs (NSAID's) for fibromyalgia is now reduced to a local therapy of NSAID in the form of ointments, gels, and injections of local anaesthetics in combination with, inter alia and lidocaine.

The removal of pain allows us to move towards the implementation of a common mobilization and health program. Mixed attention is paid to non-medicated methods

(electrotherapy, ultrasound therapy, transcutaneous neuro-stimulation, acupuncture, magnetotherapy, laser therapy, etc.), which are sometimes more effective than drug therapy [Gur A., 2006].

It is difficult enough to convince patients to include physical exercises in their complex of treatment, because they experience fatigue and pain. As studies show, aerobic exercises with a small load play a very important role in complex treatment. At the same time, excessively intense exercise or exercises of the wrong type can exacerbate the symptoms of the disease. The increase in the duration of deep sleep in patients performing them regularly has been reliably proven. High efficiency of techniques aimed at relaxation, stretching and softening of muscles was noted [Suleimanova G.P., et al., 2011; Da Costa D. et al., 2005; Gusi N. et al., 2006].

The use of cryotherapy in the treatment of fibromyalgia promotes the relaxation of muscle fibres, with a modulating effect on the body's immune system [Bettoni L. et al., 2013]. Improving microcirculation affects the mediators of pain, reducing pain, resulting in better sleep, eliminating autonomic and functional disorders [Suleimanova G.P., et al., 2011].

A special role is assigned to a diet. The majority of patients with fibromyalgia have a poor tolerance of alcohol, cereals and some other products. Improvement of one's overall health is observed when using a low-calorie diet (mainly without fats), foods enriched with magnesium and calcium, because of the possible role of these elements in the pathogenesis of the disease [Suleimanova G.P., et al., 2011].

It is advisable to include massage in a set of therapeutic measures, under the influence of which the metabolism improves, the secretory activity of the organs increases. Massage promotes the formation of biologically active substances (histamine, catecholamine, serotonin), which stimulate blood circulation in the tissues, which leads to an increase in oxygen consumption, and also removes the phenomenon of muscle spasm, facilitating the normalization of metabolism in muscles [Chinn S. et al., 2016].

A good therapeutic treatment is the use of balneotherapy in patients with fibromyalgia. Mineral water, very diverse in its physicochemical composition and properties, affects the skin and the muscular system. Hydrotherapy with fibromyalgia leads to relaxation and has a sedative effect [Gusi N. et al., 2006].

Very important is the program of support and information for patients with fibromyalgia [Grekhov R.A., et al., 2009; Suleymanova G.P. et al., 2011]. Patients should be actively involved in the therapy process and give them, as far as possible, a clear understanding of this complex disease. It is necessary to assure the patient that fibromyalgia is not a joint pathology, does not lead to deformities and does not threaten their life, that this is not a mental disorder, moreover – the symptoms of fibromyalgia are often found. The role of the doctor is growing, understanding the need for the patient to participate in a good support group, which can provide significant therapeutic assistance with a significant reduction in the symptoms of the disease in the end.

Informing, encouraging helps to guide patients through the first few weeks of treatment. In view of the likely inadequacy of the patients' response to stress, the importance of teaching patients effective coping strategies is greatly increased. It is important to discuss with patients questions about their attitudes, given that patients are character-

rized by a perfectionist inclination to complete their intended affairs no matter what physical effort it is worth. It is necessary to teach patients to measure physical activity, efforts to manage housekeeping or to do what they like with their abilities. Great importance is attached to the formation of a positive attitude toward the disease, orientation to a timely visit to the doctor, the implementation of the curative program, compliance with sleep and wakefulness [Suleimanova G.P., et al., 2011].

“Resistant” to many types of therapy, patients should be included in the treatment of “chronic pain” with the conduct of cognitive-behavioral therapy [Grekhov R.A., et al., 2009; Suleymanova G.P., et al., 2011; Tabeeva G.R., et al., 2000]. The effectiveness of the biofeedback method, which aims to teach patients to relieve muscle tension, regulate posture, and structure movements to reduce the experienced pain is proved [Buckelew S.P. et al. 1998, Ferraccioli G. et al., 1987; Molina A. et al., 1987].

When choosing the tactics of treatment of patients with FM, in particular laser therapy methods, it is also necessary to understand initially which variant of the disease should be dealt with – *primary* fibromyalgia that develops in the absence of trauma, rheumatic and non-rheumatic diseases (e.g., hypothyroidism), or a *secondary* result of background pathology.

SPECIAL METHODS OF LASER THERAPY IN VARIOUS PAIN SYNDROMES

It would seem that there are quite a lot of publications on the topic, but most of the works that consider the use of laser therapy as the main method of treating patients with various pain syndromes, the parameters of the methods are far from effective, so the results of treatment are often not impressive. This firstly concerns research. Therefore, it is extremely important to analyze various methods and the methodological mistakes made by many researchers, as well as to develop recommendations based on available scientific data, a correct understanding of the mechanisms of the BA of LILI and its clinical experience. A special section is occupied by fibromyalgia and MFPS, to which a separate chapter is devoted.

There is one fundamental difference in English-language and Russian publications on the subjects, which you must know about. If in international studies pain is a priority, the main marker of the results of treatment, and the word (pain or pain management) in most cases is listed in the title of the article, in Russian works more attention is paid to the objective control method (biochemical and hardware diagnostics), and such clinical assessments like “pain reduction”, “increase of joint mobility”, etc. are pushed alongside the matter of the course, the natural result of effective treatment. Accordingly, often pain is not assessed by objective methods, for example, using a visual analog scale (VAS), and is not included in the list of key words and the abstract of the article, therefore it is rather difficult to select publications for analysis from this point of view.

But Russian researchers are almost always aiming to find ways to improve the effectiveness of treatment, offering options for optimizing already known techniques, as well as their original ones, including, the very methodology of laser therapy in Russia, which is much better than in other countries.

Table 20 shows examples of laser therapy for patients with FM and for some pain syndromes for comparison, not excluding those works in which no result was obtained, with a full presentation of the techniques and with the most accurate indication of their parameters. Authentic terminology is also preserved in the description of some diseases, as firstly, we are talking about FM and MFPS.

Studying the table allows you to analyze the mistakes made, and readers are invited to independently understand the very different methods of influence, the pros and cons of each, the reasons for the lack of effect based on the methodology of laser therapy for pain management presented in the previous chapter. Typical reviews focus mainly on the reliability of the results obtained, which is extremely important, but we are primarily interested in the correct methodology of laser therapy.

The first thing to pay attention to is the uncertainty in the identification of TP’s and in general the painful zones (PZ), a clear and unambiguous separation, which in many works these concepts are mixed.

If you analyze the publication on the topic, including those listed in Table 20, it can be seen that in the vast majority of cases, laser light is used in the continuous mode. In

Table 20

Laser therapy for pain syndromes with effects on the TP's and PZ's

N ²	Features (localization)	Methods of research, results	Method and localization of the impact	Wavelength (nm), laser mode	Power (pulse duration*, ns)	Frequency**, Hz	Exposure per zone, minutes	Number of procedures	References
1	2	3	4	5	6	7	8	9	10
1	Neck	Pain (VAS), sensitivity (algometer), mobility, muscle tension. No result	At 3 TP and septa of the trapezius muscle bilaterally	904nm, pulse	25, 50 or 4 LD's of 27W (not specified)	1000	2	10 daily procedures on working days for 2 weeks	Altan L. et al., 2005
2	On both sides of the body, above and below the waist	Number of painful points, morning stiffness, fibromyalgia severity questionnaire (FSO), verbal scale of patient's global assessment of well-being, assessment of total myalgia. LT is effective, both in the short and long term	At 11–18 TP's and PZ's in the cervical and thoracic spine, anterior thoracic region, lower back	830nm, continuous	50mW, 2J, beam diameter of 1mm	–	1	10 daily procedures on working days for 2 weeks	Armagan O. et al., 2006
3	MFPS	Pain (VAS), control of 5-hydroxy-indoleacetic acid and serotonin + 5-hydroxytryptophan in urine. The serotonin level is increasing – an important mediator of pain suppression, LT is effective	On 4–5 TP's	904nm	13.5W (200) 1.44J/cm ²	4000	3	10 daily treatments	Ceylan Y. et al., 2004
4	MFPS, in the field of the face	Chewing parameters, threshold of pain sensitivity to pressure, pain (VAS). LT improves the performance of chewing muscles	At 5 TP's in anterior temporal and skeletal muscles: 4 TP's on the edges (cross) and 1 TP in the centre	808nm, continuous	100mW	–	19 seconds	2 times a week in the span of 4 weeks	de Moraes Maia M.L. et al., 2014
5	MFPS in the area of the TMJ	Pain (VAS). LT and the occlusive splint (cap) are equally effective for reducing pain	On the TP's in the area of the TMJ (the number is not indicated), perpendicular to the skin surface, "scanning"	1064nm, continuous	250mW, 8J/cm ²	–	20 seconds	10 daily procedures on working days for 2 weeks	Demirkol N. et al., 2015

Table 20 cont'd

1													
6	Neck department, MFPS	Pain (VAS), neck extension, lateral flexion and rotation (inclinomater and goniometer), vital activity index because of the pain in the neck. LT showed no effect when compared to the placebo	On 3 TP's bilaterally (total 6 TP's)	830nm, modulated	450mW, 58mW/cm ²	1000	2	15 procedures in the span of three weeks	Dundar U. et al., 2007				
7	FM	Clinical questionnaire FM, VAS. LT is ineffective in reducing pain	Six frequencies were used for 7 anatomical zones (anal area, abdominal region, epigastrium, chest on the left, vertical anterior region, cock's crest, area between the head and the crown).	905nm, pulsed	1W (70ns)	A 292; B 594; C 1168; D 2336; E 4672; F 73; G 146	42, one minute at each frequency	6 weeks	Fernández García R. et al., 2011				
8	TMJ	Maximum occlusion force, occlusal contact area and occlusal pressure. LT is effective in alleviating pain, but does not provide physical improvement	At a distance of 1cm from the skin, a circle with a diameter of 10cm	820nm, continuous	300mW	-	10 seconds	10 procedures 3 times a week	Gökçen-Röhlig B. et al., 2013				
9	MFPS	Pain (VAS), calculation of palpable muscle spasms and measurement by an algebraometer. LT did not show any advantages	On the TP's and PZ's (number not specified)	830nm, modulated	450mW, 60mW/cm ²	1000	2	20 procedures in the span of 4 weeks	Gül K., Onal S.A., 2009				
10	FM	The Likert scale in assessing the intensity of pain, tenderness of skin folds, morning stiffness, sleep disorders, fatigue and muscle spasms. LT is effective in FM	On 12-13 TP's	904nm	20W (200nm)	2800	3	Daily procedures on working days for 2 weeks	Gür A. et al., 2002				

Table 20 cont'd

1	2	3	4	5	6	7	8	9	10
11	FM	The Likert scale in assessing the intensity of pain, tenderness of skin folds, morning stiffness, sleep disorders, fatigue and muscle spasms. The fibromyalgia severity questionnaire (FSQ)	On 12–14 TP's	904nm	20W (200ns)	2800	3	Daily procedures on working days for 2 weeks	Gür A. et al., 2002 ⁽¹⁾
12	Neck area, chronic MFPS	LT is effective as a monomethod, and as a form of additional treatment of TP, VAS pain and neck disability, the scale of assessment of Beck's depression and the Nottingham health profile. LT is effective in alleviating pain, improving the performance and quality of life of patients with MFPS	On 2–8 TP's and PZ's	904nm	20W (200ns)	2800	3	Daily procedures on working days for 2 weeks	Gür A. et al., 2004
13	MFPS	Pain (VAS), algometry in TP, difference in algometry, thermography, and thermal asymmetry. LT is effective in alleviating pain	At 1 TP on the trapezius or scapula-raising muscle	780nm, continuous	10mW	–	3 minutes 16 seconds	10 daily procedures	Hakgüder A. et al., 2003
14	MFPS	The intensity of pain (VAS, algometry), the range of neck movement (goniometer), functional evaluation (Nottingham health profile). LT is effective for MFPS	At 3 TP in the upper trapezius muscle on both sides	633nm, continuous	2J	–	–	3 times a week, 12 procedures	Ilbuldu E. et al., 2004
15	Chewing muscles, MFPS	Pain (VAS), verbal scale. Laser acupuncture may be a treatment option, but due to the small number of participants it is impossible to make an unambiguous conclusion	Simultaneously, the acupuncture points on both sides of ST6, SI18, SI3, LI4	690nm, continuous	40mW	–	15 (?)	2 times a week, total 6 procedures in the span of 3 weeks	Katsoulis J. et al., 2010

Table 20 cont'd

1	2	3	4	5	6	7	8	9	10
22	FM	Pain (VAS), pain threshold (an algorymeter), a questionnaire of severity of fibromyalgia (FMSQ), questionnaire SF-36. LT did not show any advantages when adding to stretching exercises	On 18 TP's at right angles	830nm, continuous	30mW average, 3J/cm ²	-	-	10 procedures, two times a week	Matsutani L.A. et al., 2007
23	FM	The fibromyalgia severity questionnaire (FMSQ), physical functional performance (CS-PFP test). LT is effective in alleviating pain and increasing the range of motion of the upper body	On 7 TP's	Dual-wave, 810nm – 20%, 980nm – 80%	10W (!)	-	1	2 times a week in the span of 4 weeks	Panton L. et al., 2013
24	FM	Fibromyalgia severity questionnaire (FMSQ), pain (McGill and VAS questionnaire). LT is effective in alleviating the symptoms of FM	On 18 TP's	670nm, continuous	20mW	-	7 seconds	3 times a week in the span of 4 weeks	Ruaro J.A. et al., 2014
25	MFPS in the area of the TMJ	Pain (VAS). LT is effective in reducing pain	On the PZ's in the area of the chewing muscles, contact	660nm, continuous	17.3mW	-	6	2 times a week in the span of 3 weeks	Shirani A.M. et al., 2009
26			On tje TP's, contact (number of TP's is not specified). 6-12 procedures: One side was illuminated by an active laser, the other laser was a placebo, then both sides with an active laser	890nm, pulsed	9.8W (100ns)	1500	10		
27	MFPS	Pain (VAS, verbal scale), pain threshold measurement device, functional limitation of vital activity (e.g. manual dynamometer), patient diary (record of the presence of pain). LT is effective in reducing pain		830nm, continuous	120mW, 2.5-8J	-	-	5 daily procedures per week, upon the onset of improvement – 3 times a week. Total 6-24 procedures	Simunovic Z., 1996

Table 20 cont'd

1										
28	MFPS, neck and shoulder girdle	Pain (VAS). LT is ineffective in reducing pain	On the TP's and PZ's (up to 10), contact at right angles	830nm, continuous (part of patients) and modulated (rest)	30mW	-	1	6 procedures in the span of 5 weeks	Thorsen H. et al., 1991, 1992	
29	FM	Pain (VAS), mobility, a questionnaire of severity of fibromyalgia (FMSQ). LT and kinesiotherapy are equally effective	On 17 TP's on the back	850nm, continuous	40mW, 2J/cm ²	-	3	15 procedures, 5 times a week for 3 weeks	Vayway E.S. et al., 2016	
30	Shoulder pain	Pain (YOUR), mobility. Significant pain reduction and increased pain threshold	3 TP's in the deltoid muscle and/or the upper part of the trapezius muscle + exercise therapy	904nm, pulsed	27W, the area of the light spot is 0.07cm ²	1-1000	1.5	12 procedures every other day, 3 times a week	Yamany A.A., Salim S.E., 2011	

* - for pulsed lasers;

** - for pulsed lasers or continuous, operating in modulated mode.

some cases, with this option, you can get some effect, but it is not very pronounced, not prolonged and not always reliable, although the table shows data suggesting positive results. Attempts to increase the efficiency by increasing the power or PD of laser light are not always successful [Dundar U. et al., 2007; Gökçen-Röhlig B. et al., 2013].

We recall that with a change in the frequency of pulsed lasers, the average power proportionally varies, this is actively used to vary the ED and allows to increase the efficiency of laser action, as different frequencies (average capacities) are optimal for different methods. From this point of view, the work of L. Altan (2005) is indicative, in which the same modes are used for both TP and PZ not related to them, and in both cases the frequency of 1000Hz is not optimal. It is correct to use LILI with a variable frequency starting from 80Hz (see below), when illuminating a PZ it is permissible to use frequencies above 3000Hz only for the first 1–2 sessions, then to reduce to 80Hz for the whole course, or not to use frequencies higher 80–150Hz.

As we have already noted, in the case of FM, the pain syndrome has its own peculiarities, which makes it possible to use only complex laser therapy methods, when various methods of action directed at different pathogenetic links are involved. One of the examples of the complex approach is the technique in which the laser action of pulsed infrared LILI (890nm) is performed transcranially, on TP and AP, and the repetition rate of the pulses is varied, which is extremely important in this case [Pat. 2199357 RU]. More on this in the next section.

More about the frequencies for pulsed lasers. The first to propose the use of the variable frequency of the pulsed IR LILI was A.A. Liev et al. (1996). The essence of the technique is a gradual increase in the frequency – from 80Hz in the first procedure to 3000Hz in the 7–8th procedure, then gradually reducing to 80Hz by the 15–16th procedure. Later, the technique was improved, the limiting frequency was increased to 10.000Hz (this makes it possible to use the laser therapeutic apparatus “Lasmik”) [Moskvin S.V., 2014, 2016]. The logicity of this approach is quite understandable to anyone who knows the basics of neurophysiology of pain and the mechanisms of the LILI. But the parameters of exposure to specific PZ’s, directly related to the focus of pathology, are fundamentally different, and are not always unambiguous.

In the management of pain, exposure is extremely important. Most Russian authors recommend exposures from 20 to 60 seconds per TP, for one procedure no more than 10–12 points, for a course of at least 12–16 procedures [Bochkova I.A., 1998; Pat. 2199357 RU]. In Table 20 we see a fairly wide range of exposures used in different studies, which is not always justified. When exposed to specific PZ’s, 5 minute exposure per zone is most preferable to 2 minutes, in the case of multiple localization and/or additional use of other methods of laser therapy during the procedure.

Since the total time of the procedure can not exceed 20 minutes [Laser therapy ..., 2015], this replacement (five minutes for two minutes) is justified. The use of other exposures is not allowed in most cases, although there are some exceptions. Violation of the rule “the procedure of laser therapy should not last more than 20 minutes” is the reason for the lack of results in a number of studies [Fernández García R. et al., 2011; Vayvay E.S. et al., 2016]. In the management of pain, this is especially critical, since

the maximum response of the CNS and ANS, including the nociceptive system, occurs exactly 20 minutes from the start of the procedure.

Below are examples of some methods of laser anesthesia, questions of using them or analogs in other diseases or pathological conditions (cervicalgia, lumboschialgia, various headache variants, dysfunction of the TMJ, phantom pains, etc.) are more fully disclosed in the corresponding books, for example, appearing in the series *Effective laser therapy*. It is also necessary to understand that the methodology of laser therapy is constantly evolving, and the methods are being improved.

Household burn, injury

Pain is characterized by the presence of a diffuse and persistent pain stimulus. In this case, the time periods of the nociceptive reaction are important, consisting of an early phase of an intensive response, approximately 3 to 5 minutes, a relative decrease in the reaction (from 9 to 15 minutes) and a late phase of a stable nociceptive reaction, approximately 20 to 30 minutes [Zeredo J.L. et al., 2005].

It is known that the analgesic effect develops within 10 minutes from the beginning of the LILI and lasts about 20 minutes [Zeredo J.L. et al., 2005]. It has also been shown that laser light blocks the depolarization of nociceptive afferents [Jimbo K. et al., 1998; Wakabayashi H. et al., 1993], however, one procedure is not sufficient to suppress nerve conduction in the early phase of the reaction [Zeredo J.L. et al., 2005].

In view of the foregoing, it becomes clear that to achieve a maximum and long-lasting analgesic effect, illumination should be done twice. The first time – as soon as possible after a burn or injury, stable, distantly, exposure is two minutes. As a general rule, by the end of the procedure, the pain is reduced almost completely. Re-illumination (exposure two minutes) is carried out 10–15 minutes after the end of the first session. The time interval between sessions is individual and is *determined by the subjective feeling of a pain increase*, return of unpleasant sensations. At that moment, it is necessary to start the second session of LT.

The technique is local (on the lesion), distant. For this technique, the most optimal is the matrix pulse IR laser illuminating attachment ML-904-80: wavelength 904nm, maximum power – 60–80W, frequency 80–150Hz. With the prophylactic purpose and for the best healing of the wound, it is necessary to perform an additional 2–3 daily procedures, exposure of 2 minutes, stable, distantly, to the area of trauma, LILI parameters are the same. Laser physiotherapeutic devices are Matrix, Lasmik, Lasmik-ILBI and others.

Postherpetic neuralgia

Postherpetic neuralgia (PTN) is a complication of herpetic ganglionitis of the Gasser node and occurs in 10% of patients [Wayne A.M. et al., 1999]. Typical neuropathic pain is caused by diffused inflammation of the peripheral nerve, ganglion of the posterior root and in some cases of the spinal cord. For a long time after the resolution of acute

infection, the symptoms of chronic inflammation of the peripheral nerves, neurological deficit in the innervation zone of the posterior root and the partial destruction of the axons and myelin sheath of the affected nerve are preserved. How this creates functional changes that are characteristic of this type of pain is unknown. In several cases, relatively selective destruction of large peripheral nerves was revealed, and it was suggested that a certain role in the development of PTN is played by the inhibition of the peripheral inhibition processes carried out by these fibres.

Regarding the parameters of LT methodology, opinions differ. Some authors recommend to illuminate directly on the focal point with a continuous infrared LILI (wavelength 830nm, power 60–150mW, concentrated on a point, i.e., with maximum power density) [Kemmons O. et al., 1991; Moore K.C. et al., 2005⁽¹⁾; Sasaki K. et al., 2010; Yamada H., Ogawa H., 1995], while others prefer a red continuous LILI (633nm) [Iijima K. et al., 1991; Otsuka H. et al., 1995]. A combined version of the technique using two types of lasers is not excluded [Kemmons O., 1998; Numazawa R. et al., 1996].

H. Yamada and H. Ogawa (1995) concluded during comparative studies that for IR LILI (830nm), a power of 150mW should be selected, at which the efficiency of treatment is much higher than at 60mW. T. Hashimoto et al. (1997) showed that at 150mW, the intensity of pain decreases more rapidly if the star node is affected (Figure 15).

Regarding the red spectrum (635nm), the use of a low-power continuous LILI (10mW) is inexpedient, power of at least 40–50mW is needed. It implies only a continuous mode of operation and a local effect, stable, on the lesion centre.

One of the methods allowing to obtain a pronounced analgesic effect not only in patients with PTN, but also in trigeminal neuralgia, in radiculitis and osteoarthritis, is

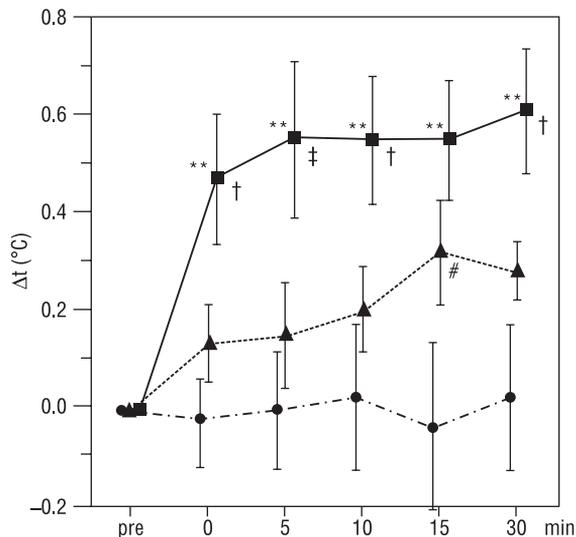


Fig. 15. Change in pain intensity in the VAS after exposure to continuous infrared LILI (830nm) with a power of 60mW (▲) and 150mW (■) relative to the placebo (●) (Hashimoto T. et al., 1997)

the effect on the skin with a continuous LILI (633nm) in projections of external radial, medial and subcutaneous nerves and lesions [Walker J., 1983].

For PTN with a facial localization, additional illumination of the projection of the star node with IR LILI is recommended [Kemmons O., 1998; Murakami F. et al., 1993; Otsuka H. et al., 1992; Tamagawa S. et al., 1996].

K. Sasaki et al. (2010) noted that the effectiveness of illumination therapy in patients with PTN is higher in the older age group (older than 70 years), as well as in patients with the duration of the disease up to 4–6 months. (87%) is almost two times higher than in those affected for more than three years (46%).

The pulsed lasers are the most promising, let us repeat, and not only are they high-intensity pulsed, they are polychromatic (600–1200) light (IPL). It is shown that pronounced anaesthesia after such illumination (locally) is observed after the first session with a small reduction in the future [Awad S.S., El-Din W.H., 2008] (Fig. 16). It is our deep conviction that the impulse regime provides the effect in this case. Influence of continuous infrared LILI (830nm, 60mW, 15 seconds per one zone or illuminating procedure) also during the first 3–4 procedures allows to obtain the maximum analgesic effect, which stabilizes later [Moore K.C. et al., 2005⁽¹⁾; Numazawa R. et al., 1996] (Figure 17), i.e., the result is not much different from even the incoherent, but pulsed light source obtained after use.

There is every reason to believe that it would be more effective for PTN's to not use pulsed IR (904 nm), but pulsed red laser light (wavelength 635nm, light pulse duration 100–150ns, power 5W), but only relevant comparative studies can confirm this. In any case, the frequency for pulsed lasers should be sufficiently high, at least at the beginning of the course, the first 1–3 sessions, or a variant with a gradually varying frequency from procedure to procedure should be used.

For the treatment of patients with PTN, firstly is pulsed IR LILI (matrix with 10 laser diodes, 904nm wavelength, pulse power 15W, frequency 4000Hz) were used by

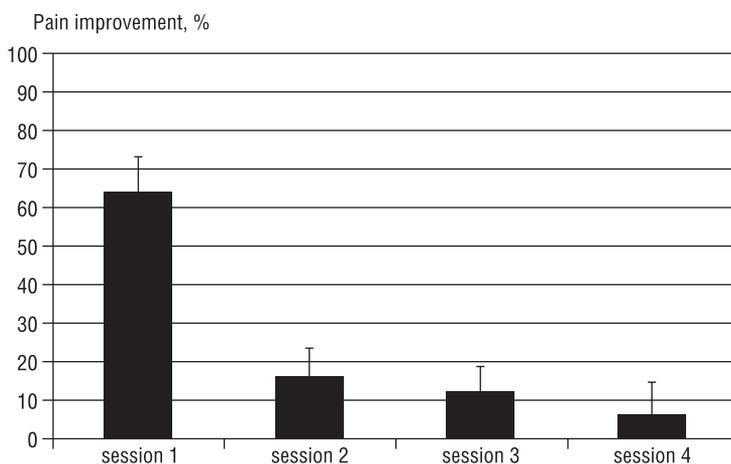


Fig. 16. Pain intensity in the first 4 days after illumination of PHN patients by pulsed incoherent polychromatic light (Awad S.S., El-Din W.H., 2008)

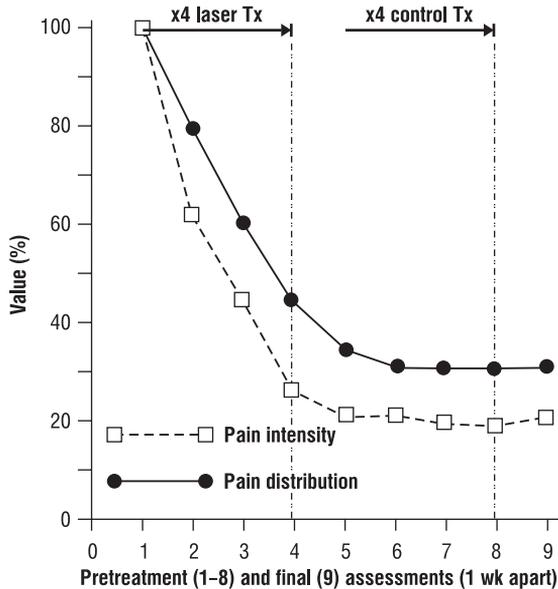


Fig. 17. Pain intensity after several sessions of illuminating PHN patients with continuous LILI (Moore K.C. et al., 2005⁽¹⁾)

L. McKibbin and R. Downie (1991). Although the chosen time parameters of the procedure (20 minutes for one area, 5 procedures in 4 hours) raise doubts, nevertheless the effect occurred, and was preserved, according to the authors, for up to a year.

O. Kemmotsu et al. (1991) in a double-blind clinical trial showed that the maximum analgesic effect in patients with PTN is observed precisely after a 5-minute exposure to continuous infrared LILI, while an increase in local temperature is 2–3% (Figure 18). This pattern is confirmed by other authors [Hashimoto T. et al., 1997] (Fig. 15). The saturation effect indicates a reciprocal compensatory reaction of the organism, which is triggered.

Antiviral action is observed only if treatment begins within the first 72 hours from the onset of herpetic eruptions and alongside the prescription of appropriate generic drugs (anticonvulsants and antidepressants). The first treatment course of combined LT is 4 weeks (no less), procedures are conducted on working days, and a second course is absolutely necessary, and no later than two months after the end of the first.

First course of laser therapy

The technique is local (on the lesion, the zone of maximum soreness), contact. All 20 daily procedures are carried out on working days. The laser physiotherapeutic apparatus *Lasmik*, the matrix pulse IR laser illuminating attachment ML-904-80 (904nm wavelength, pulse mode, maximum power – 60–80W, exposure 5 minutes), stable, contact through the TMA. The frequency of 10.000Hz is the first 5 sessions, then decreases as the pain syndrome is reduced, for example, 3000Hz – 6–10th sessions, 1000Hz – 11–15th sessions, 150–300Hz – 16–20th sessions.

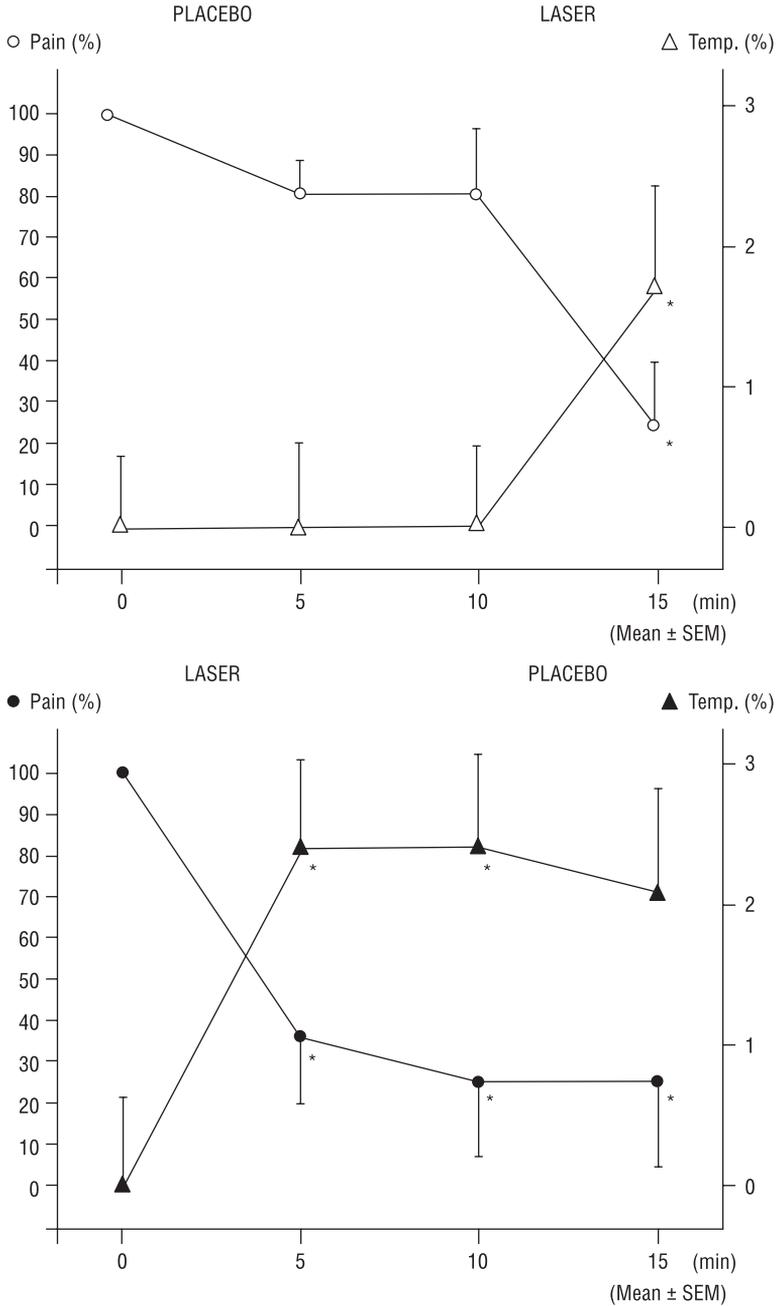


Fig. 18. Change in pain intensity (●) and local temperature (▲) at the site of exposure to continuous infrared LILI (830nm, 60mW) in patients with PHN (Kemmons O. et al., 1991)

The first 10 sessions, additionally, daily illuminate on the projection of the supraclavicular area to the left – 2 minutes, the thymus – 1.5 minutes and the spleen – 1 minute (Fig. 19, zones 1, 2, 3 respectively). The laser physiotherapeutic apparatus “Lasmik”, the matrix pulse IR laser illuminating attachment ML-904-80 (904nm wavelength, pulse mode, maximum power – 60–80W, frequency 80–150Hz), stable, contact through the TMA.

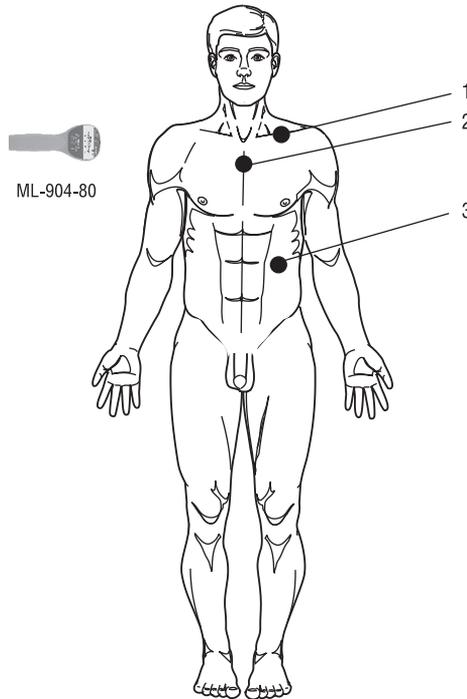


Fig. 19. Areas of influence of LILI in PHN

Repeated course of laser therapy

The technique is local, contact. The LT scheme depends on the patient’s condition, with the recurrence of the disease the first-year, procedure is repeated, and in the absence of pain, preventive therapy is carried out, including 10 sessions a day on the projection of the thymus – 1.5 min and the spleen – 1 min (Figure 19, zones 2, 3, respectively), (see the parameters of the procedure above). On the same days, the effect is local on the area of the lesion. The laser physiotherapeutic apparatus Lasmik, the matrix pulse IR laser illuminating ML-904-80 (904nm wavelength, pulse mode, frequency 150–300Hz, maximum power 60–80W, exposure five minutes), stable, contact through the TMA. In the case of a partial preservation of pain, the first sessions of exposure to the foci of lesions are carried out at a frequency of 10.000 Hz, gradually reducing further, for a total of at least 15 daily procedures.

Neuralgia of the trigeminal nerve

Chronic disease, manifested by attacks of intense shooting pain in the zones of innervation of the trigeminal nerve. The pain can arise suddenly, reminiscent of a sudden electric shock, immediately manifesting to its maximum intensity, and just as suddenly stop. Attacks of pain are stereotypical and have a duration of a few seconds to two minutes. The pain has intractable intensity and is provoked by eating, talking, touching (washing, brushing teeth, etc.) or occurs spontaneously. Interstitial pain of varying intensity, as well as disorders of sensitivity and paresthesia, are characteristic of adherent trigeminal neuropathy; the latter often develops after the injection-destructive treatment of neuralgia.

Isolate the primary (essential, idiopathic, typical) and secondary (symptomatic) trigeminal neuralgia. The neuralgia of the trigeminal nerve, which develops independently of any earlier painful processes (the most frequent variant), is attributed to the first, is increasingly explained by the tunnel-compression (ischemic) mechanism; The second – symptomatic complexes that are a complication of the primary disease: odontogenic origin associated with circulatory disorders in the brainstem area, *Herpes zoster* (Gasser node ganglionitis), diseases of the paranasal sinuses, basal meningitis, formations in the posterior or middle cranial fossa [Golubev V. L., Vein A.N., 2002].

Most often, in international studies, in the methods of eliminating the pain syndrome in this pathology there is a continuous infrared LILI (830nm, power from 40mW and higher), the effect is performed on palpable areas [Eckerdal A., Bastian H.L., 1996]. A fairly good analgesic effect is shown after exposure to pulsed infrared LILI (904nm) with a maximum frequency (10.000Hz, an average power of 30mW, an exposure of two minutes per point), but only in the absence of effect at lower values (the first procedures are performed at frequencies 2–4 times smaller) [Hansen H.J., Thorøe U., 1990].

The complex method

A course of 8–10 daily procedures.

Laser therapy is performed daily on the points of exit of the affected branches of the trigeminal nerve, on 3–4 painful zones (Figure 20, along the lines 1, 2, 3), and on the region of the upper cervical sympathetic unit – zone 4 (under the angle of the lower jaw) symmetrically. Using the laser physiotherapeutic device Lasmik, pulse IR laser illuminating attachment LO-904-20 (wavelength 904nm, pulse power 10–15W, frequency 80–150Hz), exposure 1.5–2 minutes per zone, stable, contact-mirror technique through a mirror attachment ZN-35.

In addition, the area of the upper cervical and cervicothoracic (stellate) sympathetic nodes (10–20 seconds per zone) is applied, then on the apex of the mastoid process (exposure 20–30 seconds). The laser physiotherapeutic apparatus Lasmik, laser illuminating attachment LO-904-20 (904nm wavelength, pulsed power 10–15W, frequency 80–150Hz), stable, contact-mirror technique through the ZN-35 mirror attachment.

Given that the blood supply of the facial nerve is carried out from the internal auditory artery (the main branch), the stony artery (the branch of the middle meningeal, which in turn is the branch of the maxillary artery), the stylomastriac artery (from the

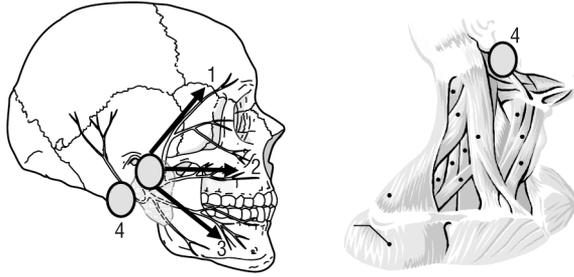


Fig. 20. Exposed zones for trigeminal neuralgia: 1st branch (ocular nerve) – the superciliary arch in the superior orbital fissure of the skull; 2d branch (maxillary nerve) – the center of the pterygomaxillary fossa; 3d branch (mandibular nerve) – the area of mental foramen of the mandible; 4 – the projection of the superior cervical sympathetic ganglion

external carotid artery), these arteries should also be influenced by LILI, and to improve the metabolism in the liver and pancreas, for two minutes per zone. The laser physiotherapeutic apparatus *Lasmik*, the matrix pulse IR laser illuminating attachment ML-904-80 (904nm wavelength, pulse mode, maximum power – 60–80W, frequency 80–150Hz), stable, contact through the TMA.

The issue of frequency variability (medium power) is disputed, since a decrease in pain in this case can be achieved both through the elimination of the inflammatory process, and by the inhibitory effect of LILI on the transmission of nerve impulses. In the first case, a minimum ED is required, in the second case, a maximum ED is required. If in the third method a mode change is not expected in principle, then in the methods 1 and 2 it is permissible, as an option, to use high frequencies (for the pulsed mode) in the first procedures and/or during the course treatment if there is no result or individual features of the course of the disease after 3–4 procedures.

Tietze syndrome (Rib Costochondritis)

A disease of unclear etiology, characterized by a tumor-like growth in one or more rib cartilages in the area of their connection with the sternum, accompanied by severe pains, especially manifested with movements and deep breathing.

The technique is local (on the lesion, the zone of maximum soreness), contact. The laser physiotherapeutic apparatus “Lasmik”, the matrix pulse IR laser illuminating attachment ML-904-80 (904nm wavelength, pulse mode, maximum power – 60–80W, exposure 5 minutes), stable, contact through the TMA. Frequency 10.000Hz – the first 1–2 procedures, and 3000Hz – the remaining sessions. The course is 10–12 daily procedures.

Gout (gout arthritis)

The etiology and pathogenesis of this disease is not fully understood, it is assumed that it is based on disturbances of the metabolism of uric acid, which results in an

increase in the level of its salts in the blood, followed by the deposition of uric acid compounds in the joints of various locations, where acute attacks of inflammation develop with the formation of gouty granules and Tophi. Effective treatment programs are not currently developed.

The disease, according to V.V. Skupchenko (1991), refers to the tonic type, i.e., when laser therapy is used, the maximum energy parameters of LILI are required. The tasks of treatment include not only an anaesthetic effect, but through a generalized (systemic) response of the body, the normalization of the metabolism of uric acid, i.e., the elimination of the very cause of the onset of pain.

It is required to conduct at least two rather long courses with subsequent periodic (annual) repetition. The impact is performed on the four joints symmetrically, even if the pain is localized in only one or two. The total time of the procedure is limited to 20 minutes, with an exposure of five minutes (just this time!) on one joint, therefore the total number of exposure zones should not exceed four. The parameters of the procedure are completely identical for all courses.

First course of laser therapy

No less than four weeks. All 20 daily sessions are held on working days, on joints at the site of maximum soreness (four symmetrical joints), contact with a small compression (i.e., the laser diode directly touches the skin), stable. Laser physiotherapeutic apparatus “Lasmik”, pulse IR-laser illuminating attachment LO-904-100 (904nm wavelength, pulsed operation mode, maximum power 80–90W, exposure five minutes). Frequency 10.000Hz – the first 10 sessions, 3000Hz – the next 10 sessions.

Repeated courses of laser therapy

The second course is carried out two months after the start of the first course, or approximately one month after the end of the first course. The third course is six months after the start of the first course, and then once a year the procedures are repeated as prophylaxis for a shortened program (5–7 daily procedures), and in case of an exacerbation, a full course of laser therapy (15–20 procedures) is necessary.

Complex regional pain syndrome

Complex regional pain syndrome (CRPS) is a disease characterized by severe pain and trophic changes in the limb. CRPS Type I usually develops after a microtrauma or long-term immobilization (the imposition of longi, gypsum, yshib, trauma of the soft tissues of the limb, etc.) not limited by damage to one peripheral nerve and a clearly disproportionate effect on the magnitude of this effect. It is believed that CRPS type II is diagnosed with damage to the peripheral nerve or one of its branches, which is often accompanied by Causalgia [Novikov A.V., Yakhno N.N., 2001].

In many cases, reflex sympathetic dystrophy can develop for no apparent reason. The mechanisms of the appearance of this disease are still unknown. The role of increased regional activity of the sympathetic nervous system has been widely recognized. According to one of the accepted theories, as a result of trauma in the central nervous

system, the nervous centres responsible for sympathetic innervation of the limb are hyperactivated, which leads to an increase in the sympathetic tone, vasospasm in the affected arm or leg, and the development of trophic disorders.

At the heart of the development of spontaneous (stimulus-independent) pain is the activation of primary C-afferents. The potential for action on the membrane of neurons develops as a result of the functioning of an ion pump, which carries the transport of sodium ions to sodium channels. The development of sympathetically caused pain is associated with two mechanisms. First, after damage to the peripheral nerve on the membranes of damaged and intact C-fibre axons, α -adrenergic receptors (normal on these fibres are absent), sensitive to circulating catecholamines emerging from terminals of postganglionic sympathetic fibres, begin to appear. Secondly, nerve damage also causes sympathetic fibres to germinate into the posterior root node where they are braided in the form of a basket of sensitive neuron bodies, and thus activation of sympathetic terminals provokes the activation of sensitive fibres. However, not all spontaneous pain develops only because of the activation of the primary nociceptors. At the heart of the development of spontaneous pain is also involved the mechanisms associated with disruption of braking processes at the level of the rear horn. Neurons of the horn of the spinal cord receive information from the primary afferents. Activity of neurons of hind horns is determined not only by exciting peripheral stimulation, but also by inhibitory influences, which can be spinal or descending central. Thus, an increase in inhibitory influences leads to a decrease in the activity of the neurons of the horn, which is the basis for the gate control of the incoming afferentation. The defeat of the peripheral nerve can reduce inhibitory control of the neurons of the hindbones in various ways. Nerve damage leads to a decrease in the concentration of GABA, which has a braking effect, which causes a disruption in the regulation of GABA-ergic and opiate receptors located on the presynaptic membranes of the primary sensory neurons and on postsynaptic membranes of the hindbone neurons. In addition, as a result of the development of excitotoxic reactions leading to the development of mechanisms of apoptosis or programmed death of cells associated with peripheral nerve injury, intercalary neurons localized in the second plate of hindlimb cells die, many of which perform a bremsstrahlung function. As a result of these processes, secondary sensory afferents lose their braking mechanisms and begin to generate pathological impulses that are transmitted to the central nervous system even in the absence of activity in the primary sensitive afferents [Novikov A.V., Yakhno N.N., 2001].

Dynamic hyperalgesia is a consequence of the increased response of sensitive neurons of the horn of the spinal cord to stimulation carried out along the A δ -fibres from low-threshold mechanoreceptors. Normally, the activation of low-threshold mechanoreceptors is not associated with pain sensations. The development of dynamic hyperalgesia (allodynia) is associated with the development of central sensitization. At the heart of central sensitization is the persistent depolarization of membranes. The main exciting neurotransmitter in primary afferents is glutamate. There are two types of glutamate receptors on the postsynaptic membrane of the sensory neurons of the hindbones of the spinal cord: the first is the amino-3-hydroxy-5-methyloxazole-4-propionic acid (AMPA receptor) receptors and the second is N-methyl-D-aspartate

receptors. Activation of nociceptors leads to the release of glutamate from presynaptic membranes, and, interacting with postsynaptic glutamate AMPA receptors, causes rapid depolarization of the membranes of the neurons of the posterior horn and, when the excitation threshold is exceeded, generates an action potential. This mechanism underlies the conduct of normal nociceptive stimuli. Another type of glutamate receptor is N-methyl-D-aspartate receptors (NMDA receptors) bound to the calcium channels of cell membranes that are in an inactive state. These channels are inactive, because their pores, like a stopper, are blocked by magnesium ions. When the channel is blocked by a magnesium ion, glutamate can not activate it. However, with the development of transient depolarization of the membrane associated with the function of nociception, these channels open, providing the transportation of calcium, and after the restoration of the polarity again close. In the case of damage to the peripheral nerve, the processes of polarization and depolarization of cell membranes undergo profound changes. Substance P, which is together with glutamate in the central terminals of the primary afferents, is excreted and activates neurokinin-1 receptors, as a result of which the depolarization time increases and the intracellular concentration of calcium ions increases. This process activates the protein kinase C, which phosphorylates protein fragments of NMDA receptors, and these proteins, in turn, bind to magnesium ions and open channels through which calcium begins to actively enter the cell, increasing the membrane's excitability with the development of persistent depolarization. In addition, calcium ions, entering the cell, activate intracellular enzymes, including nitric oxide synthase (oxidase synthase), which causes the synthesis of nitric oxide (NO). Nitric oxide plays the role of a freely diffusing neurotransmitter that dramatically increases pain transmission. It is with the neurotransmitter functions of nitric oxide that the phenomenon of "inflation" is associated, which is characterized by a sharp increase in the amplitude of action potentials on the membrane of the sensory neurons of the horn of the spinal cord [Novikov A.V., Yakhno N.N., 2001].

Central sensitization is characterized by three signs: the appearance of a zone of secondary hyperalgesia; increased response to suprathreshold stimuli; and the appearance of a response to subliminal stimulation. These changes are clinically expressed by the appearance of hyperalgesia on pain stimuli, which is much wider in the damage zones, and includes the effect of hyperalgesia on neo-stimulation. The spread of pain beyond the innervation zone of the affected nerve is a manifestation of non-psychogenic disorders, but the most common sign of central sensitization. Cold and mechanical hyperalgesia are also manifestations of central sensitization. In some patients, allodynia (dynamic hyperalgesia) can be observed in the absence of other signs of spontaneous pain. In this case, the activation of the neurons of the hindbones associated with the A δ -fibres develops not at the expense of stimulation of the low-threshold mechanoreceptors, but at the expense of disturbing the mechanisms that provide the central inhibitory effects. These mechanisms are connected, first, with descending serotonin and noradrenergic influences. Serotonin acts on 5HT receptors, adrenergic effects are realized through spinal α 2 receptors, which inhibit the release of substance P from the central terminals of the primary afferents. Secondly, it is the phenomenon of "germination" (or "sprouting") of A-fibres in the horn of the spinal cord. Normally, the central

terminus of A-fibres is found in all plates of the hindbrain cells, with the exception of the II plate, which receives central terminology solely from nociceptive C-afferents. Damage to the peripheral nerve causes atrophy of C-fibres and induces germination of the central terminals of A-fibres in the second plate. Functionally significant in this process is that normally the neurons of the second plate receive only nociceptive information and the receipt of sky stimulation can be mistakenly regarded by the nervous system as pain. This mechanism is an anatomical substrate of allodynia. Thirdly, it is a mechanism for switching the phenotype. Its essence is that, as a result of damage to the nerve, its phenotypic properties may change. These properties of the neuron, associated with the synthesis of proteins used for its growth and maintenance of vital activity, are controlled by the growth factor of the nerves. Nerve growth factor retrograde with axoplasmic current is transported from the innervated tissues to the body of a sensitive neuron, where it regulates the concentration of neuropeptides performing the function of transmitters. Traumatic axon injury or a block of axoplasmic transport caused by the use of cytostatics causes profound phenotypic changes associated with the dissociation of bonds, which normally the cell constantly maintains with innervated tissues. After damage to the nerve, the Schwann cells of the A δ -fibres are differentiated, and instead of myelin, they begin to synthesize neuropeptides, such as substance P and calcitonin-gene-releasing peptide, which normally occur only in the primary affinities of C- and A δ -fibres. As a result of such changes in the phenotypic properties, the stimulation of low-threshold mechanoreceptors associated with A δ -fibres can cause the release of substance P, the interaction of the substance with postsynaptic membranes of the spinal cord posterior horns with their subsequent hyperexcitability, which normally occurs only as a reaction to nociceptive stimuli. The development of primary hyperalgesia is associated with a decrease in the excitation threshold in the peripheral terminals of nociceptors and is called peripheral sensitization. As a result of damage to the nerve, antidromic impulses along the sensory fibres develop. These antidromic impulses stimulate the release from the peripheral terminals of substance P and calcitonin-gene-releasing peptide, which cause peripheral sensitization of both damaged and undamaged fibres [Novikov A.V., Yakhno N.N., 2001].

From all the above and the available knowledge about the mechanisms of the BA of LILI, it can be concluded that there is a fundamental possibility of using laser therapy in this case.

In any case, treatment of patients with CRPS should be comprehensive, including medical therapy, physiotherapy, massage, physical therapy and acupuncture. The fundamental component of therapy is the conduct of sympathetic blockades. With pain in the hand, the local anaesthetic solution is injected in close proximity to the stellate ganglion, which innervates the upper limb. With pains in the lower limb, a blockage of the lumbar sympathetic chain along the spine is performed. The effect of the sympathetic blockade, as a general rule, lasts several days and exceeds the duration of action of the local anaesthetic by several times. Patients in the early stages of the disease after the course of treatment blockage often complete recovery. In the case of a persistent course of the disease, a surgical operation can be performed, which consists in removing the sympathetic ganglion taking part in the innervation of the involved limb. With

a pronounced prolonged pain syndrome, electrostimulation of the posterior columns of the spinal cord has a good effect [Novikov A.V., Yakhno N.N., 2001].

Treatment is long enough, requiring patience from both the patient and the doctor, is necessarily comprehensive, using, among other things, various physiotherapy methods [Bengston K., 1997; Smart K.M. et al., 2016]. Only by using the whole arsenal of medical measures, you can reduce the likelihood of developing severe functional disorders of the limb, which often enough leads to the disease.

In this case, from the light of a light bulb, even if it is polarized, it has no use, only “a sense of warmth” [Basford J.R. et al., 2003; Ide Y., 2009], the peculiarities of the disease make it necessary to use monochromatic coherent light, moreover, non-standard methods of laser therapy.

S. Giavelli et al. (1996) compared several variants of illumination therapy in patients with geriatric CRPS (there are no age and gender distributions) in the shoulder region (Table 21). The technique is not presented in sufficient detail, it is known only that the power of the CO₂ laser (10.600nm) was 3500mW, and the HeNe Laser (633nm) was 4.5mW, the shoulder area (10 × 15cm) and the arms (10 × 10cm), scanning at a speed of 2.5–2.8cm/s, 5 sessions per week. How the energy parameters presented in the table were calculated is also unknown. Therefore, it is not necessary to say that optimal regimes have been found.

Table 21

Clinical results of laser therapy in patients with geriatric CRPS (Giavelli S. et al., 1996)

Helium-Neon Laser (633nm)				
ED, J/cm²	Results			Total patients
	Very good and good	Sufficient	Small or missing	
0.311	7 (38.9%)	9 (50%)	2 (11.1%)	18
0.229	5 (50%)	4 (40%)	1 (10%)	10
CO₂-laser (10.600nm)				
ED, J/cm²	Results			Total patients
	Very good and good	Sufficient	Small or missing	
425	18 (50%)	12 (33.3%)	6 (16.7%)	36
153	14 (63.6%)	4 (18.2%)	4 (18.2%)	22
137	42 (77.8%)	8 (14.8%)	4 (7.4%)	54

In another study, it was shown that the effectiveness of laser therapy in patients with CRPS is statistically significantly higher in comparison with interference currents. While the parameters of the technique, as it so often happens, are far from optimal: the wavelength of 810nm, the modulated mode (frequencies of 70, 640 and 5000Hz), on eight zones along the joint and PZ of the affected area with ED 1.5J/cm² (the exposure is not indicated, although this is a critically important parameter of the technique), the results are quite good. Additionally, kinesiotherapy (dosed to the pain threshold) was performed for 30 minutes, twice a day. The course consisted of 10 daily procedures

five days a week (two weeks) and 10 procedures every other day [Dimitrijevic I.M. et al., 2014]. The authors of the work also refer to the data of other Serbian researchers [Lazovic M., 1997].

Special methods of laser therapy for CRPS, unfortunately, have not yet been developed in detail, clinical trials are required, but the theoretical basis is quite sufficient. It is possible that the use of an ML-904-80 matrix pulsed IR laser attachment with frequency variation and illumination areas will allow a fairly pronounced effect.

Plantar (plantar) fasciitis

The pathological process, often called “calcaneal spur”, with severe pain syndrome, caused by degenerative-dystrophic changes in the plantar aponeurosis at the place of attachment to the calcaneus. According to some reports, about 10% of patients seeking help with diseases of the musculoskeletal system are patients from this category, and their main complaint is pain in the calcaneal region, the main symptom of the disease.

Plantar fasciitis is the most common cause of pain in the heel, typical for middle-aged people. The disease also occurs in young people who spend a lot of time on their feet, for example, athletes and soldiers. The disease can affect one foot or both feet. Most patients with plantar fasciitis experience pain in their first steps after rising from bed or after prolonged sitting. After the first few steps, pain and stiffness may decrease, but pain may intensify throughout the day, most often during climbing stairs or after standing for a long period of time [Harkess L.B., Felder-Johnson K., 2007].

Until now, experts have not formed a consensus on the causes of the disease. Often plantar fasciitis is a consequence of the involuntary processes of the human body and is found as an anatomical feature in middle-aged and elderly people [Blokhin V.N., Vinogradova T.P., 1997].

The most important condition for the effectiveness of treatment is to ensure the alleviating of the painful area and improve the blood supply to the foot tissues. For this purpose, according to the indications, individual orthopedic insoles are appointed with the laying of the inner and outer longitudinal arches, a recess and a soft lining under the heel. The most valuable is alleviating with the help of orthopedic shoes with a deepening in the heel. With the back spur, the indentation is made in the back. As a temporary measure, you can recommend wearing shoes without a back. The treatment package also includes warm baths with sea salt, soap, soda, therapeutic gymnastics and foot and throat massages [Kasinets S.S., 2012].

Injections of NSAID’s do not give the desired improvement, and if there is any effect, then it quickly relapses the disease [Shutov Y.M. et al., 2015; Huang H.H. et al., 2000], injections of cortisone into the medial lobe of the calcaneus can lead to irreversible atrophy of the fat pad of the heel, which, in turn, leads the patient to disability [Akhmerova K.S. et al., 2015]. If the therapy is unsuccessful, a variety of surgical interventions are used that can not be considered ideal, since the developing cicatricial process in the tissues and subsequent mechanical disorders can reflexively support the secondary pain syndrome for a long time [Tsymbal A.N., Tsymbal A.V., 2012].

There is a less traumatic method of treating hepatic spurs with surgical lasers. After local anaesthesia, a perforation with a surgical laser of a spur, a perforated bursa, and a partial plantar aponeurosis in the area of attachment to the spur for 10 seconds (laser type is not indicated) is performed after local anaesthesia through a needle for intraosseous anaesthesia. The course of treatment consists of three manipulations (one per week). After each manipulation, the limb is immobilized by a removable gypsum lance in the plantar flexion position. Patients during the treatment period (three weeks) use crutches. Thermal effects on the tissues surrounding the spur cause their destruction and aseptic inflammation, the outcome of which is obliteration of the bursa and scar-sclerotic degeneration of the tissues surrounding the spur. In addition, in the process of thermal destruction sensitive sensory nerve endings, which leads to the disappearance of pain in the spur area immediately after manipulation. The purpose of anaesthetics is therefore not effective [Pat. 2206285 RU]. A similar technique was implemented using a holmium (Ho: YAG) laser (wavelength 2100nm, pulse mode, pulse duration 350µs, power 40W), as it had its advantages, the authors also indicate the non-traumatic nature of the surgery [Smith W.K. et al., 2001]. Nevertheless, according to our data, this method of treatment is not applied in clinical practice because of inexpediency.

The results of the use of extracorporeal shock wave therapy (ESWT) have also proved to be ambiguous, depending on the setting of the study and the technique of conducting, the success varies diametrically from the absence of positive results to the complete relief of the pain syndrome [Tsymbol A.N., 2013; Shutov Y.M., et al., 2015; Shockwave therapy for pain ..., 2016]. In addition, for this procedure, only imported expensive devices are used, which explains the high cost of the procedure, despite the fact that, and we repeat, there was a lack of results.

Y.A. Rodin and A.A. Ushakov (2007) suggest between sessions ESWT to conduct magnetolaser therapy “to prevent exacerbation of the pain syndrome.” Other authors recommend this additionally to ESWT, because after such an impact, the pain is not only not stopped, but pain intensification is often increased up to two days, 10 daily laser phoresis procedures with bee venom are performed below the medial malleolus, the zone below the lateral malleolus, Achilles tendon and lifting of the foot and heel [Pat. 9882 BY]. Although the LILI parameters are highly controversial (wavelength 633nm, continuous mode, power density 130–140mW/cm², exposure 10 minutes), the idea is attractive and promising. It is only necessary to select the appropriate drugs and use effective methods of laser illumination. But all this does not save the situation, it would be more correct to prescribe only laser therapy, perhaps in a correlated or combined version, but without using a knowingly ineffective treatment (ESWT).

In other words, the problem is not solved within the framework of standard approaches to treatment, the more surprising is why so far no one has paid attention to an exceptionally effective and simple method of treating plantar fasciitis patients – laser therapy? Perhaps the reason is that in Russia, according to our data, there have been no studies proving this fact, there are only separate recommendations of specialists and positive feedback from those who use laser therapy in their daily practice [Kachkovsky M.A., Chernova N.E., 2010; Prityko D.A., et al., 2013].

Our international colleagues have long understood that not only with plantar fasciitis, but also with related inflammatory diseases such as tendonitis and bursitis, NSAID's and other pharmaceuticals are ineffective and the best treatment is combining exercise therapy with various physiotherapy methods, including laser therapy [Huang H.H., et al., 2000]. Although earlier questions arose about the reliability of some studies [Stuber K., Kristmanson K., 2006], comparing the effectiveness of laser and shock wave therapy is simply pointless. For example, with lateral epicondylitis and some other soft tissue diseases, none of the latest systematic reviews found any clear evidence that shock wave therapy is superior to placebo, and among other physiotherapy methods, priority is given to laser therapy [Bjordal J.M. et al., 2008; Buchbinder R. et al., 2006; Dion S. et al., 2017; Y.H. et al., 2016].

Table 22 shows the parameters of laser therapeutic techniques and the results of treatment of patients with plantar fasciitis.

Of a small number of international studies, some important conclusions can still be drawn, for example, it is quite certain to say that a continuous LILI in red (633nm) [Jastifer J.R. et al., 2014, Macias D.M. et al., 2015], especially in the IR spectrum (830nm) [Basford J.R. et al., 1998], does not allow the obtaining of a sufficiently pronounced therapeutic effect in patients with plantar fasciitis. Only pulsed LILI mode of red or IR spectrum and only with adequate parameters of the technique. In particular, as J.M. Bjordal et al. (2001) stated, it is necessary to adjust the energy characteristics depending on the wavelength of the laser light.

In a RCT using a continuous LILI of the red spectrum, some reliable, positive results were demonstrated, but it is useless to utilise it as such efficiency cannot be expected from laser therapy.

The technique is contact-mirror, stable. The laser physiotherapeutic apparatus Lasmik, the pulsed infrared laser emitting attachment LO-904-20 (904nm wavelength, pulse mode, frequency 80–150Hz, power 10–15W), stable, contact through the mirror attachment ZN-35 or the magnetic nozzle ZM-50.

Alternatively, you can use a matrix pulse IR laser illumination head ML-904-80 or a matrix pulse laser emitting attachment ML-635-40 of the red spectrum (wavelength 635nm, power 40W, light pulse duration 100–150ns). Prospects of pulsed LILI in the visible range are very obvious, despite the fact that the practice of its application is so far incomparable with the mass distribution of devices operating in the IR spectrum.

The first 3 procedures are performed daily for 1.5–2 minutes per zone of projection of the heel spur on the plantar surface of the foot, at the place of attachment of the Achilles tendon to the calcaneus (Fig. 21, zone 3). From the fourth procedure, a painful zone is added on the inner or outer surface of the heel area, which must be determined by palpation, although the patient often points to it (Figure 21, zone 1 or 2 – the most common localizations).

The course is up to 10 daily procedures, although most often it's 3–5. In resistant cases, after a break of two weeks, treatment (laser therapy with the same parameters) is repeated (a course of 10 daily procedures).

Belarusian colleagues quite logically recommend to add to the local effect an ILBI (wavelength 635nm, 1mW, 20 minutes, five daily procedures) [Pat. 7752 BY].

Table 22

Laser therapy with plantar fasciitis, the results of several RCT's

Methods of evaluation, results	Wavelength, nm (laser mode)	Power, mW	Exposure, minutes	Area of light spot, energy or ED	Number of impact zones and procedures	References
VAS, the result was absent	830 (continuous)	30	0.5	0.03cm ²	1 zone, 3 weekly procedures, 4 weeks	Basford J.R. et al., 1998
VAS, index of the function of the foot. Minimal results (first control after 2 weeks), the effect persisted to six weeks, was absent in all after 12 months	635 (continuous)	17	10	1.476J/cm ²	4 zones, 1 procedure	Jastifer J.R. et al., 2014
VAS and thickness of the plantar fascia. Significant effect (pain reduction), confirmed by the objective control	904 (pulse)	4x60 (pulse power 4x20W, 5000Hz)	157.5 seconds	1 and 3cm ²	-	Kiritisi O. et al., 2010
VAS, index of the function of the foot. In the placebo group, LED's were used instead of lasers. Minimal results	635 (continuous)	17	10	-	2 procedures per week, 3 weeks	Macias D.M. et al., 2015
VAS. There were no statistically significant differences between LT and steroid injections	904 (pulse)	3000Hz	30 seconds	-	10	Yüzer S. et al., 2006

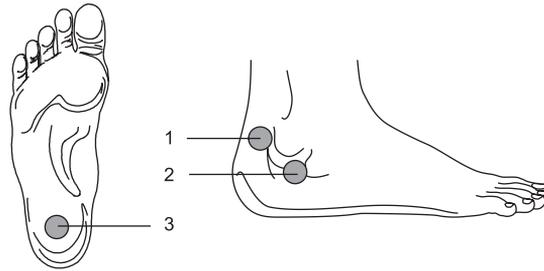


Fig. 21. Zones of a laser therapeutic effect with plantar fasciitis

It seems to be promising to use laser phoresis, but it is necessary to choose the appropriate drugs. For example, a solution of hydrocortisone hemisuccinate, whose ultrasonic and electrophoresis is proposed in one of the methods for the treatment of patients with heel spurs [Pat. 13319 BY], a lot of information on this topic is presented in the review, close in subject (sports medicine and trauma) [Khadartsev A.A., et al., 2016]. The optimal parameters of laser action during laser phoresis can be found in our works [Moskvin S.V., Konchugova T.V., 2012; Moskvin S.V. et al., 2010], and it's was LILI that is able to provide the best percutaneous administration of various substances, proved long ago [Minenkov A.A., 1989].

LASER THERAPY OF PATIENTS WITH FIBROMYALGIA

According to modern ideas, FM and MFPS are only stages of a single process of chronic muscle pain formation [Malykhin M.Y., Vasilenko A.M., 2017], however the methodology of laser treatment is very different depending on the localization of the pain syndrome, its association with various lesions of the musculoskeletal system and/or internal organs. We also consider it more appropriate to preserve the author's terminology when citing relevant publications, including those used to justify LT methods.

Despite the significant number of drug and non-pharmacological methods of treatment for patients with FM, their effectiveness is not good enough. In addition, long-term use of analgesics, sedatives and non-steroidal anti-inflammatory drugs (NSAID's) leads to the development of side effects aggravating the severity of the condition [Bochkova I.A., 1998]. In this regard, the actual task is to develop new methods of treatment which are more effective and without negative consequences.

Laser therapy is the most universal therapeutic factor, it has no side effects and absolute contraindications, while unlike anaesthetics, it affects not one link of the pain reception, but practically the whole hierarchy of mechanisms of its origin and regulation [Moskvin S.V., 2016].

Practically all those who are involved in pain syndromes recommend firstly to carry out laser illuminating of TP's and directly to the lesion centres, if any, or to the projection of internal organs, if violations are detected there.

The effect on TP's is the main method of laser therapy for patients with FM and with MFPS, and other methods of influence, for example, locally, in the projection of internal organs, laser acupuncture, paravertebral and ILBI, are additional. This is the main difference between the treatment regimens listed below, from those recommended for other variants of the pain syndrome (see the previous section). It is also necessary to take into account that the methods of laser action on TP's significantly differ from the LILI parameters used for other methods of action.

Methodologies and substantiation of the parameters of the methods in the vast majority of publications are not available either due to a lack of understanding of the BA of LILI mechanisms, or an ignorance of the physiological basis for the onset of pain syndrome. Almost all specialists realised their first unsuccessful attempts to understand that increasing the illuminating time does not lead to the desired result. This is a positive point, however, with the other components of the methodology the situation is very unfavorable. Parameters of LT methods proposed in publications of different levels are extremely diverse, sometimes diametrically opposite in the logic of implementation, but have common features – their authors in most cases are guided not by the medical and biological justification of the chosen parameters, knowledge of known BA of LILI mechanisms and the pathogenesis of the disease, but proceed exclusively from technical capabilities of existing equipment and anaesthesia is perceived as an end in itself. This option is implemented through an increase to the maximum possible power level and

by reducing the area of the PD spotlight. Indeed, the desired result (pain reduction) is most often achieved quickly enough, however, the effect is short-term, but there is no recovery as such, the patient does not get rid of the ailment for a long time, at least for several months.

Also, the lack of uniformity, the “standard” of terminology, as already noted above, hampers the development of the methodology for treating patients with FM and with MFPS. Uncertainty in relation to TP’s (*trigger points* or *tender points*) and generally painful zones (PZ), their clear and unambiguous separation often leads to mistakes in the choice of treatment tactics and methodology (Table 20).

The majority of specialists only use the method of laser illuminating of the TP’s, which is not always effective. Indeed, it has been shown that the illumination of TP’s by a continuous LILI of the red spectrum (633nm) causes changes in sympathetic activity accompanied by an increase in skin resistance at the site of exposure [Snyder-Mackler L. et al., 1986, 1989], the latency of peripheral sensory nerve fibres, which leads to a decrease in the conduction velocity of the nerve impulse, resulting in a reduction in pain [Snyder-Mackler L., Bork E., 1988]. In the previous section, some other studies on the topic are also given. But only this effect is not enough, optimization is necessary both in the search for other options (ways) for illumination of the TP’s, and for the combined use of different LT methods.

One of the methods, which we have repeatedly heard of positive feedback and reports on many years of successful experience in clinical practice, is intramuscular TP illumination through a light guide. In the cases when patients have a prolonged course of the disease with TP’s, neurodystrophic and tunnel syndromes, when patients suffer from other concomitant diseases, and the effectiveness of traditional methods of treatment is low, a complex methodology is recommended: ILBI-635 (standard technique) + *laser blockade*. Before each treatment procedure, after locating the patient and diagnosing the “key” muscle or zone with the method of palpation and taking into account the anatomical landmarks, foci of local TP are determined, into which, after treatment of the hands and the zone of exposure, a sterile light guide with a needle (KIVL-01) is introduced into the alcohol. LILI parameters: wavelength 635 nm, continuous mode, power 5–8 mW, time of action for one zone 2–3 min. After the extraction of the light guide, the site of action is re-treated with alcohol and the next point is illuminated (in one day 3–5 TP). After the procedure, the patient rests in the ward for at least 1 hour. On a course of treatment of 6–8 daily procedures, the ILBI with laser blockades is carried out every other day [Ulashchik VS And others, 2003].

Specialized literature discusses the role of metabolic shifts in the etiopathogenesis of FM, in particular, energy processes. This aspect is considered from the position of the analysis of the mechanism of the onset of TP, for example, in tissue biopsies taken from these zones, a decrease in the content of high-energy phosphates was detected [Bengtsson A. et al., 1986⁽¹⁾; Henriksson K.G., Bengtsson A., 1990] and a change in phosphodiesterase activity [Jubrias S.A. et al., 1994]. On the local hypoxia is evidence of the spectrographic study of muscles [Bengtsson A. et al., 1986].

In the study by I.A. Bochkova (1998) showed that after the course of illumination therapy, 82% of patients undergo a normalization of the isoenzymatic spectrum of

lactate dehydrogenase (LDH), which contributes to the improvement of energy supply of muscle tissue, decreases the number of TP's and decreases the painfulness of the remaining TP's. An important conclusion that objectively confirms the influence of LILI on the state of the TP zone.

In addition to the pain syndrome typical for FM, complex treatment with multiple LT methods is required, analysis of studies and own clinical experience allow us to conclude that the effect of continuous LILI on TP's is ineffective, it is necessary to use pulse mode and infrared (IR) spectrum (duration A light pulse of 100–150ns, a pulsed power of 10–15W, a wavelength of 904nm). The same opinion is shared by a number of other authors [Bochkova I.A., 1998; Pat. 2199357 RU].

The use of an integrated approach, which involves the widest possible range of LT methods, allows the restoration of abnormalities in the functioning of various organs and systems of the human body, which, in addition to directly blocking pain, eliminates the causes of the disease. This “universality” predetermines the exceptional effectiveness of illumination therapy in the reliable elimination of pain syndromes of various types and is ensured, among other things, by varying the parameters of the techniques. Equally important, after a properly organized course of laser therapy, the effect persists for a long period of time – months and years – so you can talk about treatment as such, i.e., when the patient forgets about the disease if not forever, then for a very long time [Kochetkov A.V. et al., 2012; Moskvina S.V., 2016].

The fact of the effect of laser light on TP's has been established for a long time, this is described in detail in the previous section, where appropriate studies are given, but it is more important for us to understand how to illuminate these zones most optimally.

Table 20 (the previous section) does not include the only experimental work showing that laser illumination of New Zealand rabbits (contact at five TP's and muscle tension zones, 780nm, continuous mode, 30mW, 30 seconds ($4.5\text{J}/\text{cm}^2$) or three minutes ($27\text{J}/\text{cm}^2$, five consecutive days) affects some biochemical parameters associated with pain (β -endorphin, substance P, tumor necrosis factor TNF- α and cyclooxygenase-2). Different biochemical parameters differ to varying degrees with an increase or decrease in ED [Hsieh Y.L., et al., 2015.] However, one important fact is not taken into account in the study, namely that the change in ED as a result of arithmetical actions (J/cm^2) in the case of exposure differentiation varies nonlinearly with the final result, it is permissible to vary only the power and with significant restrictions on the area of the light spot. In other words, with formally identical values of ED's obtained at different exposures, the effect can be diametrically opposite, occur as stimulation of some process, as well as its inhibition. This is one of the most common mistakes of many authors.

In work with reference to Russian studies, the possibility of using ILBI-635 (wavelength 633–635nm, power 1–2mW) for the treatment of patients with FM [Momenzadeh S. et al., 2015] is justified. The authors motivate their choice by such well-known results of laser illumination as normalization of the immune system, improvement of the rheological properties of blood and trophic provision of tissues. This promising direction needs to be developed.

Improvement of microcirculation and oxygen supply of various tissues after ILBI-635 is closely connected with the positive influence of LILI on metabolism: the oxidation of energy materials – glucose, pyruvate, lactate – increases [Skupchenko V.V., 1991]. However, quite often and very successfully, an intravenous version of the method of laser blood-illuminating is replaced by non-invasive (transcutaneous) methods, using matrix red pulsed lasers (wavelength 635nm, pulse power 40W, matrix of 8 laser diodes located 4 in 2 Series, an area of 8cm², a pulse duration of 100–150ns, a frequency of 80–150Hz) [Kochetkov A.V., et al., 2012; Pat. 2539535].

A.M. Wayne et al. (1999) consider that high efficiency of classical acupuncture (needles) as monotherapy is not observed, but the method can be recommended in complex treatment as an additional one. This recommendation probably applies to laser acupuncture.

As one example of an integrated approach, the application of a combined methodology, one very interesting Russian patent can be cited, in which the combined LT methodology is used, affecting different areas, including TP's and acupuncture points (AP), as well as a multifrequency mode with varying frequencies of the pulse IR LILI [Pat. 2199357 RU].

According to the claims of the invention, the technique is implemented through a combined effect on TP's and areas of neurohistophyrosis of pathologically altered muscles by pulsed IR (890–904nm) laser illumination using a complex mode of modulation, bursts of pulses of 8–12Hz with a repetition rate of 28–33kHz (***Fixed typo, in the original document – Hz***). At the same time, the effect is exerted on remote TP taking into account the irrational features of the formation of pain syndrome. In addition, the effect is carried out on the head zones in the region of the projection of the frontal, parietal and occipital lobes with a frequency of 80–1500Hz, alternately with a penetration depth of 2–4mm. Then, with a penetration depth of 6–8mm, laser illumination is simultaneously applied to the points of the foot and hand, corresponding to the projection of the pain sites according to Su Jok therapy systems [Pat. 2199357 RU]. In the description of the invention, some very important points of the technique are clarified, for example, that the LT technique is contact-mirror, stable, it is impossible to shift the laser emitting attachment from the impact zone, the LILI impulse power is 4–6W. The term “depth of penetration” raises many questions, and this needs to be considered separately.

Exposure to one TP – can be from 30 seconds to “achieve a significant analgesic effect.” A magnetic mirror nozzle with an induction of 25–50 mT is used. Exposure to the areas of the head in the region of the projection of the frontal, parietal and occipital lobes was determined more accurately – 60 seconds (one minutes), “using alternately non-magnetic mirror nozzles with a depth of penetration of 2–4mm, and then magnetic axial attachments with a penetration depth of 6–8mm”. The example also shows the repetition rate of pulses – 80Hz. From the passage about the “depth of penetration” it is clear only that “nonmagnetic mirror attachments” are ZN-35 or analog, but the rest is formulated so that the used attachments penetrate the head to a different distance [Pat. 2199357 RU]. This is a frank stylistic blunder, most likely, the authors believe that with the use of magnetic attachments, the depth of LILI penetration increases,

a misconception that has long been refuted. Also, the indicated distances (“depth of penetration”) for laser light with the indicated parameters are really far from the truth, in fact they are an order of magnitude larger [Moskvin S.V., 2014].

However, two clinical examples bring additional clarity to the methodology, which we give with a slight correction.

Example 1. Patient N, age 45 years.

Complaints of pain in the area of the outer corner of the eye, above the brow on the left; a diffused pain inside the head, periodic pain in the neck, increasing after prolonged physical exertion.

Anamnesis morbi. Pain worries for four years, first appeared after long work at the computer, constantly taking analgesics and finilepsin. He was treated for a long time with the diagnosis of trigeminal neuralgia. The cranial nerves are normal, the pupils are S = D, the exit points of the trigeminal nerve are painless.

Examination. There is a limitation of active and passive movements in the cervical spine. The pain is noticeably worse when the head is tilted forward and down. At palpation, the tension and soreness of the posterior muscles of the neck are revealed, most pronounced in the neck muscle of the neck. In the upper part of the left belt muscle of the neck, sharply painful, condensed areas of muscles are revealed, with irritation of which there is a sharp pain inside the head, in the region of the eyeball and the left superciliary region. Tendon reflexes S = D, sensitivity disorders are not detected, coordination tests are performed satisfactorily.

Methodology of LT

The effect on the three identified TP’s in the region of the upper third of the belt muscle and on the area of the outer corner of the eye in the zone of the most pain for 30 seconds per zone by pulsed infrared LILI (with a magnetic nozzle) in the multifrequency mode.

Then the effect on the head area:

1st session – along the middle line of the head simultaneously with two laser emitting attachments with mirror nozzles (pulse IR LILI, wavelength 890–904nm, power 4–5W, frequency 80Hz, exposure 30 seconds).

2nd session – on the temporal areas simultaneously with two laser emitting attachments with magnetic mirror nozzles (pulsed IR LILI, wavelength 890–904nm, power 4–5W, frequency 80Hz, exposure 30 seconds).

3rd session – on the occipital region of the head with a laser emitting attachment with a magnetic mirror nozzle (pulse infrared LILI, wavelength 890–904nm, power 4–5W, frequency 80Hz, exposure 30 seconds).

Laser acupuncture was also performed with a laser emitting attachment with an acupuncture nozzle (pulsed IR LILI, wavelength 890–904nm, power 3–4W, frequency 80Hz, exposure 30 seconds) for the following AP:

1st session: GI4 (hegu); GI11 (qu-chi); VB20 (Feng Chi); V10 (Tian Zhu).

2nd session: E36 (tszu san li); VG16 (feng fu); IG4 (Wan Gu); IG16 (tian chuan);

3rd session: V60 (kun lun); V40 (wei zhong), VG20 (bye hui), VB21 (jian jing), TR15 (tian liao), VG14 (da chuyi).

Sessions were repeated daily.

Additionally, the effect was according to the Su-Jock therapy system on painful points in the region of the thumbs of the right and left hands with a laser emitting attachment with an acupuncture nozzle (pulsed infrared LILI, wavelength 890–904nm, power 3–4W, frequency 80Hz, exposure 10 seconds).

Example 2. Patient X, age 62 years.

For 6 months, severe pains in the right shoulder joint and a feeling of stiffness in the neck were disturbed.

Examination. Patient is emotional, tearful, has astenizirovana in neurological status which is determined by the tension and soreness of the periart trigger muscle in the right shoulder joint, limitation of motion in the right shoulder joint, palpation revealed the most painful muscle seals that are in the right infraspinatus muscles and in muscle, lifting blade. When these sites were irritated, a typical pain periarth appeared.

Methodology of LT (difference in localization of TP's and acupuncture prescription)

The effect on the three identified TP's in the region of the upper third of the subarachnoid muscle and on the area of the outer corner of the eye in the zone of the most pain for 30 seconds per zone by pulsed infrared LILI (with a magnetic nozzle) in a multi-part mode.

Then, the effect on the head region (the technique is identical to that described in the first example).

Laser acupuncture was also performed with a laser emitting attachment with an acupuncture nozzle (pulsed IR LILI, wavelength 890–904nm, power 3–4W, frequency 80Hz, exposure 30 seconds) for the following AP:

1st session: GI4 (hegu); GI11 (qu-chi); VG14 (yes zhui); VB21 (jian jing);

2nd session: E36 (tszu san li); VG16 (feng fu); IG4 (Wan Gu); IG16 (tian chuan);

3rd session: V60 (kun lun); V40 (wei zhong), VG20 (bye hui), VB21 (jian jing), TR15 (tian liao), VG14 (da chuyi).

Sessions were repeated daily.

Additionally, the effect was according to the Su-Jock therapy system on painful points in the region of the thumbs of the right and left hands with a laser emitting attachment with an acupuncture nozzle (pulsed infrared LILI, wavelength 890–904nm, power 3–4W, frequency 80Hz, exposure 10 seconds). This technique can be applied with some correction, since the data is non-reproducible in the description.

The peculiarities of therapy of elderly people with MFPS, burdened with somatic pathology, necessitate the use of a wide range of therapeutic effects. A complex method comprising of laser therapy, electroneurostimulation, ozonotherapy, individual orthopedic correction, manipulation, diet, acupuncture and herbal medicine. The complex and individual approach allows to significantly improve the functioning of the respiratory, cardiovascular, digestive, osteoarticular and immune systems of the body, as well as the instrumental-laboratory indicators, which ultimately leads to a significant improvement in the parameters of homeostasis. Attention is focused on the fact that it is the non-drug therapies that can significantly improve the quality of treatment of patients, without resorting to expensive medical equipment and medicines [Kudaeva L.M., Fridman V.A., 2014].

With FM, there are no clear structural and functional disorders from the muscular tissue. Specialized literature discusses the role of metabolic shifts in the etiopathogenesis of FM, in particular, energy processes. This aspect is considered from the position of the analysis of the mechanism of the onset of TP's, for example, in tissue biopsies taken from these zones, a decrease in the content of high-energy phosphates was detected [Bengtsson A. et al., 1986⁽¹⁾; Henriksson K.G., Bengtsson A., 1990] and a change in phosphodiesterase activity [Jubrias S.A. et al., 1994], and data from the spectrographic study of muscles testify to local hypoxia [Bengtsson A. et al., 1986].

In connection with the fact that tissue hypoxia is accompanied by a change in the activity of enzymes involved in oxidation-reduction processes, the study of enzymatic maintenance of glycolysis reactions in FM is of particular interest. Possible disturbances from the general activity and isoenzyme spectrum of the key enzyme glycolysis-lactate dehydrogenase can be considered as one of the possible mechanisms for the development of metabolic disorders, leading in turn to the occurrence of chronic pain [Bochkova I.A., 1998]. Confirmation of this perspective is the data indicating the contents of the growth of pyruvate with a simultaneous reduction of lactate levels, adenosine triphosphate and muscle fractions in serum LDH in patients with FM [Eisinger J. et al., 1994].

It is also known that after laser acupuncture – points F12 (chi mai), F13 (chzhan men) and F14 (chi men) – the initially reduced activity of lactate dehydrogenase in patients with chronic persistent hepatitis rises due to isoenzyme LDH5 [Simkina T.V. et al., 2007]. Improvement of microcirculation and oxygen supply of various tissues after laser blood illumination is also closely related to the positive influence of LILI on the metabolism: the oxidation of energy materials – glucose, pyruvate, lactate – increases [Skupchenko V.V., 1991].

All of the foregoing served as the basis for a study aimed at evaluating the effectiveness of complex treatment of patients with FM, consisting of the combined use of laser therapy with the effect on TP's and drug therapy with NSAID's with antidepressants. An analysis of the nature of the isoenzyme shifts on the part of LDH and an assessment of the possibility of using this enzyme test for the diagnosis and monitoring of the effectiveness of treatment. All clinical indicators are usually expressed in points, and laboratory data in absolute values [Bochkova I.A., 1998].

The most common clinical indicators for FM are: the intensity of pain, the degree of stiffness, the degree of fatigue, the intensity of the headache, the severity of sleep disturbance and the number of painful zones determined by palpation. The first five indicators were assessed using a visual analog scale (VAS) and expressed in scores (from 0 to 10). Among the mandatory instrumental methods of examination were X-rays of the spine and joints, electrocardiography and ultrasound examination of the thyroid gland. The standard laboratory examination included the determination of blood parameters: general analysis, biochemical parameters, C-reactive protein content (capillary precipitation method), rheumatoid factor (latex agglutination reaction), antinuclear creatine kinase activity factor, thyroid hormone levels; General analysis of urine. A special laboratory examination included the determination of the total LDH activity in a direct and reverse reaction using a spectrographic method based on a direct optical

Varburg test. The principle of the method lies in the different absorption spectrum of the oxidized and reduced NAD forms at 340nm. Quantitative analysis of LDH was performed by electrophoretic separation in a polyacrylamide gel (PAGE). When the PAGE was separated, Tris-glycine buffer pH 8.3 was used. The most optimal was the separation according to the Ditz and Lubrano method, in which a 5.5% separating gel was used and the serum was peeled after adding a 40% sucrose solution to the electrode buffer solution. Electrophoresis was performed at 4 °C and a current strength of 2–3mA per tube for 40–60 minutes. After electrophoresis, the gels were incubated for 0.5–2 hours in the dark at a temperature of 37 °C in a substrate mixture. Densitometry of the fractions was carried out using a densitometer “Chromoscan-3” (“Toyce Loeb1”, England) [Bochkova I.A., 1998].

Influence of pulsed IR LRI (wavelength 890nm, pulse power 5–7W, frequency 80–300Hz, exposure 10–20 seconds for one TP, total for a session of no more than 10 points) was conducted daily. Drug therapy included NSAID’s (piroxicam 20mg per day) and tricyclic antidepressants (amitriptyline 10–25mg per day). The full course of treatment was 12–16 procedures. This technique was used to treat the majority of patients with FM, with half of them having only illumination therapy (group 2), and the other half of the patients underwent combined therapy with NSAID’s and antidepressants (group 3). The control group of patients received only drug therapy (group 1).

When comparing the effectiveness of these methods, the severity of the main clinical symptoms (in points), the number of painful points were taken into account, and the dynamics of LDH isoenzymes, primarily LDG4 and LDH5, was analyzed.

The revealed relationship between clinical and isoenzyme indices indicates that the level of LDH4 and LDG5 objectively reflects the severity of the fibromyalgic syndrome, therefore, it can be used for the objective diagnosis of this condition and for evaluating the effectiveness of treatment.

The results of a statistical analysis of the obtained data showed that the effectiveness of treatment in the compared groups of patients was not the same. As follows in Table’s 23 and 24, the most significant dynamics of clinical indicators were obtained in the third group of patients (complex treatment). All clinical indicators decreased reliably, the number of detectable TP decreased significantly. Along with this, there was a significant dynamic of the LDH4 and LDH5 levels, which reached the values of this index in healthy individuals.

With a total evaluation of the effectiveness of treatment for clinical signs, a positive effect was noted in 82% of patients and in 72% a normalization of the isoenzyme spectrum of LDH was observed.

As for patients who received local illumination therapy without taking medication (group 2), the results were comparable to those in group 1 of patients who received only medication. The majority of clinical indices in patients of the 2nd group underwent significant changes, however the intensity of the headache and the degree of sleep disturbance decreased insignificantly. The number of painful zones decreased reliably (Tables 25 and 26).

It is important to emphasize that in this group of patients the statistically significant dynamics of isoenzymes LDG4 and LDG5 was noted. Their level increased significant-

Table 23

Dynamics of the clinical parameters in patients of FM in combination of LT with the intake of medications (Bochkova I.A., 1998)

Parameter	Amount	Pain	Stiffness	Fatigue	Head aches	Sleep Disturbance	Amount of points
Before treatment	32	7.36 ± 0.1	4.47 ± 0.12	7.63 ± 0.1	4.27 ± 0.11	4.97 ± 0.13	11.53 ± 1.29
After treatment	32	3.63 ± 0.18	2.9 ± 0.29	3 ± 0.21	2.91 ± 0.19	2.66 ± 0.18	5.8 ± 1.32

Table 24

Dynamics of the isoenzyme composition in patients with FM in combination with LT and the intake of medications (Bochkova I.A., 1998)

LDH	Amount	LDH1	LDH2	LDH3	LDH4	LDH5
Before treatment	32	27.75 ± 1.82	37.24 ± 1.79	22.48 ± 1.88	7.39 ± 1.89	5.14 ± 1.45
After treatment	32	25.21 ± 1.27	33.35 ± 1.23	20.17 ± 1.23	12.04 ± 1.27	9.23 ± 1.31
Health	45	24.09 ± 1.31	32.12 ± 1.27	20.20 ± 1.32	13.63 ± 1.21	10.05 ± 1.69

Table 25

Dynamics of the clinical parameters in patients with FM under the influence of laser therapy alone (Bochkova I.A., 1998)

Indicators	Amount	Pain	Stiffness	Fatigue	Head aches	Sleep Disturbance	Amount of points
Before treatment	32	7.36 ± 0.1	4.47 ± 0.12	7.63 ± 0.1	4.27 ± 0.11	4.97 ± 0.13	11.53 ± 1.29
After treatment	32	5.67 ± 0.22	2.13 ± 0.13	5.47 ± 0.21	4.10 ± 0.20	4.66 ± 0.18	6.67 ± 1.31

Table 26

Dynamics of the isoenzymatic composition of LDH in patients with FM under the influence of laser therapy alone (Bochkova I.A., 1998)

LDH	Amount	LDH1	LDH2	LDH3	LDH4	LDH5
Before treatment	32	2.75 ± 1.82	37.24 ± 1.79	22.48 ± 1.88	7.39 ± 1.89	5.14 ± 1.45
After treatment	32	25.31 ± 1.24	33.34 ± 1.35	20.26 ± 1.32	12.06 ± 1.22	9.03 ± 1.31
Health	45	24.09 ± 1.31	32.12 ± 1.27	20.2 ± 2.32	13.63 ± 1.21	10.05 ± 1.69

ly in 43% of patients. A total evaluation of the effectiveness of treatment by clinical indicators showed that “improvement” and “significant improvement” were noted by 65% of patients after the course of laser therapy.

In the group of patients who received only medication, with positive dynamics of subjective symptoms, there was no significant reduction in even the number of painful points (Table 27). In addition, there were no significant changes in the content of isoenzymes LDG4 and LDG5 in serum (Table 28).

If 62% of the patients of the 1st group had a positive result in the subjective evaluation, then the normalization of the isoenzyme spectrum of LDH was observed only in 15.5% of cases.

As it follows from the obtained data, LT contributes to reliable dynamics of objective parameters of the severity of fibromyalgic syndrome, which indicates the advantage of this method in terms of therapeutic effectiveness. In addition, laser therapy, unlike drug treatment, was not accompanied by adverse reactions. The combination of LT with drug treatment significantly increases the therapeutic effect [Bochkova I.A., 1998].

There is every reason to assume that the effect of LILI on TP's, along with direct or indirect analgesic effect, contributes to the normalization of microcirculatory disorders in tissues, reduces the degree of tissue hypoxia and stimulates the activity of energy metabolism enzymes, in particular LDH. The increase in LDH4 and LDH5 levels contributes to the improvement of the energy supply of muscle tissue, especially in conditions of hypoxia. Thus, laser therapy with TP's in combination with the intake of NSAID's and antidepressants is an effective method for treating patients with FM. The inclusion of this method in the complex therapy of FM promotes the improvement of the quality of treatment of patients and the reduction of complications from drug treatment [Bochkova I.A., 1998].

International colleagues also studied the possibility of using physiotherapeutic methods, including laser therapy, to treat patients with FM [Carville S.F., Choy E.H.S., 2008]. The impact of IR LILI (904nm, 20W, 200ns, frequency 2800Hz, exposure – 3 minutes per zone), which effectively reduces pain, muscle spasms and morning stiffness, was most preferable [Gür A. et al., 2002]. For anaesthesia, laser acupuncture is also recommended (HeNe laser, 633nm, for each of 12 AP for 15 seconds) [Waylonis G.W. et al., 1988]. Continuous infrared LILI (830nm, 30–50mW) has only a certain positive effect only on one of the indicators of the quality of life of patients (morning stiffness) [Armagan O. et al., 2006; Matsutani L.A. et al., 2007].

Nevertheless, in the protocol for randomized controlled trials (RCT), which P. de T.C. Carvalho et al. (2012) suggests, there is not a word about the optimization of laser exposure and the need to take into account the experience of previous researchers in the planning of new ones. This leads to the emergence of RCT's with deliberately unacceptable and ineffective parameters of LT, for example, a wavelength of 670nm, a continuous mode, a power of 20mW, an exposure of seven seconds per zone (TP's, total of 18), daily for four weeks, and patients, of course, do not have receive any pain-relieving effects [Ruaro J.A. et al., 2014].

Table 27

Dynamics of clinical indicators in patients with FM who took only medication (Bochkova I.A., 1998)

Indicator	Amount	Pain	Stiffness	Fatigue	Head aches	Sleep disturbance	Amount of points
Before treatment	32	7.36 ± 0.1	4.47 ± 0.11	7.63 ± 0.11	4.27 ± 0.18	4.66 ± 0.13	11.53 ± 1.29
After treatment	32	4.23 ± 0.17	3.8 ± 0.14	4.1 ± 0.18	3.66 ± 0.22	2.5 ± 0.16	9.26 ± 1.43

Table 28

Dynamics of the isoenzyme composition of LDH in patients with FM who only took medication (Bochkova I.A., 1998)

LDH	Amount	LDH1	LDH2	LDH3	LDH4	LDH5
Before treatment	32	27.75 ± 1.82	37.24 ± 1.79	22.48 ± 1.88	7.39 ± 1.89	5.14 ± 1.45
After treatment	32	26.95 ± 1.15	36.99 ± 1.37	21.87 ± 1.23	8.11 ± 1.19	6.08 ± 1.31
Health	45	24.09 ± 1.31	32.12 ± 1.27	20.2 ± 1.32	13.63 ± 1.21	10.05 ± 1.69

Special methods of laser therapy in patients with fibromyalgia

The course of laser therapy consists of 12–16 procedures, it is recommended to be carried out alongside of taking antidepressants. In the first days of treatment positive dynamics of clinical indices is noted, pain intensity, stiffness, fatigue, sleep disturbances, headache, tenderness and number of TP's are decreased, however, a stable clinical effect is achieved only after the course is over.

Method 1. Impact on TP

The parameters of the procedure are presented in Table 29. The pulsed infrared laser illuminating attachment LO-904-20 of the laser physiotherapeutic apparatus *Lasmik* is used.

Table 29

**Parameters of the method of LT for patients with fibromyalgia when exposed to TP's
(Bochkova I.A., 1998, with changes)**

Parameters	Values	Usage Notes
Laser wavelength, nm (spectrum)	904 (IR)	–
Laser operating mode	Pulse	–
Duration of light pulse, ns	100–150	–
Illumination power, W	10–15	–
Power density, W/cm ² (surface area 1cm ²)	10–15	–
Frequency, Hz	80–150	–
Exposure per zone, seconds	20–30	–
Number of affected areas	To 10	–
Localization	TP	–
Method	Contact-mirror	Through the mirror nozzle ZN-35
Number of procedures per course	12–15	Daily

Method 2. Impact on TP

A.A. Liev et al. (1996) showed that the MFPS, due to the vertebrogenic pathology, is characterized by the presence of active TP's. The source of this group of pain syndromes are muscles of the upper extremities, lumbar and gluteal regions, usually accompanied by pain of another localization (reflected pain). It is necessary to search for TP's and analyze the pain pattern for an accurate diagnosis of the myofascial syndrome. The palpable active and latent TP's, area of lesion of the spinal-motor segments are revealed, the data of the X-ray studies are taken into account.

Depending on the area of exposure, T.V. Apakidze (1998) used continuous red laser light (633nm) and pulsed IR LILI (890nm), exposures also differed significantly, from 60 to 256 seconds.

One of the most important results of the study is the proof of the high analgesic effect of laser therapy. Depending on the version of the MFPS, 26.3–32.6% of patients

Table 30

Basic parameters of the procedure for patients with FM or with MFPS (Moskvin S.V., 2016)

Parameters	Value	Usage Notes
Laser wavelength, nm (spectrum)	904 (IR)	On the active TP
	635 (red)	On the latent TP
Laser operating mode	Pulsed	–
Duration of light pulse, ns	100–150	–
Illumination power, W	10–15	–
	5	–
Power density, W/cm ² (surface area 1cm ²)	10–15	–
	5	–
Frequency, Hz	See Table 31 below	–
Exposure per zone, minutes	1	–
Number of affected areas	To 10	Simultaneous action with two illuminating heads on two TP's is allowed
Localization	Trigger points	See Fig. 22–30
Method	Contact-mirror	Through the mirror nozzle ZN-35
Number of procedures per course	15	Daily

Table 31

Changes in frequency for pulsed infrared LILI (904 nm) when exposed to TP

Procedure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Frequency, Hz	80	150	300	600	1500	3000	10.000	10.000	3000	1500	600	300	150	80	80

were reported to have an abstinence syndrome, the soreness of the vertebral-motor segments decreased by an average of almost three times, with muscular-tonic form reduction more than five-fold.

When analyzing hemorheological indices, it was established that all the studied parameters (concentration of fibrinogen, endogenous heparin and antithrombin III) were approaching the norm after the course of illumination therapy. It is interesting that this is recorded both in patients with vasoconstrictive and with a vasodilator variant of MFPS.

Analysis of the AOS state in patients objectively testified to the positive effect of LT on the dynamics of the antioxidant status, a decrease in the level of free radical oxidation was observed, normalization of MDA concentration in erythrocytes and plasma of blood occurred in the discharge; in patients with initially large deviations in the LPO system, the tendency to increase antioxidative properties of blood.

The general results of treatment of patients are presented in Table 32.

A follow-up of patients with control and basic groups indicates a more stable therapeutic effect after the course of illumination therapy, which is manifested in a smaller number of cases of exacerbations – 1.8 times, a decrease in the average duration of the exacerbation period of 14.8 ± 0.1 and 9.4 ± 0.6 days, an increase in the duration of

remission – 5.6 ± 0.08 and 8.3 ± 0.1 months, in the control and main groups, respectively [Apakidze T.V., 1998].

Table 32

The effectiveness of laser therapy with MFPS (Apakidze T.V., 1998)

Result	Groups	
	Control	Basic
Without change	33.3	15.4
Minor improvement	27.6	13.4
Improvement	23.2	22.1
Significant improvement	15.9	49.1

The areas where the TP's of the lower part of the body are most often located at the MFPS, caused by vertebrogenic pathology, are shown in Fig. 22–30.

Laser therapy can be used as a basic method of treatment, and also as an additional method in the complex therapy of patients with chronic vertebrogenic lumboschialgia. In conjunction with arthromotor reactions (sacroiliac joint, hip joint, knee joint), regardless of the location of the TP's, the effect of LILI-paravertebral at the level of $L_{III}-S_I$ must be preliminarily carried out according to a known technique.

On the region with latent TP's, pulsed LILI's of the red spectrum (laser emitting attachment LO-635-5 with A-3 packing), 635nm wavelength, maximum power (5W), frequency constant at all sessions – 80Hz.

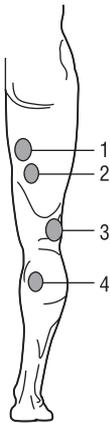


Fig. 22. TP of the biceps of the thigh (1, 2), semimembranosus muscle (3) and popliteal muscle (4)

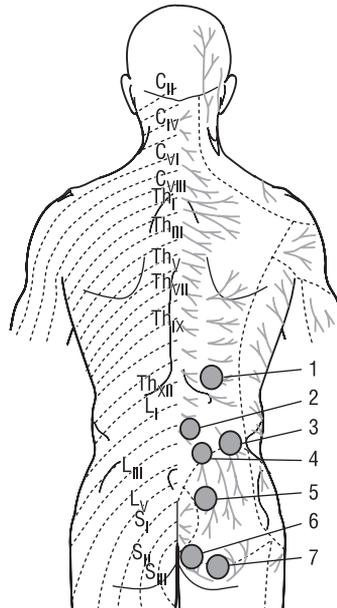


Fig. 23. TP of the lumbar quadrate muscle (1, 3), back extensors (2, 4), parts of the gluteus maximus (5, 6, 7)

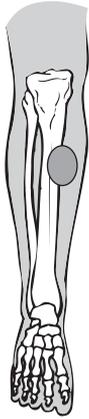


Fig. 24. TP of the tibialis anterior muscle (1)

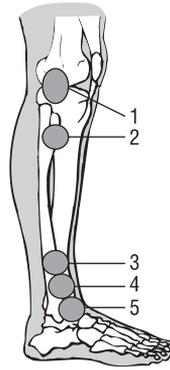


Fig. 25. TP of the knee joint collateral ligament (1); TP of the peroneal muscle: 2 – *m. peroneus longus*, 3 – *m. peroneus brevis*, 4, 5 – *m. peroneus tertius*

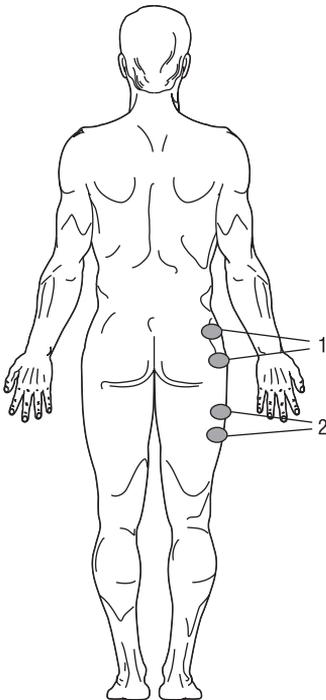


Fig. 26. TP of the muscles straining broad fascia of the thigh (1); combined TP of the muscle straining broad fascia thigh and vastus lateralis muscle (2)

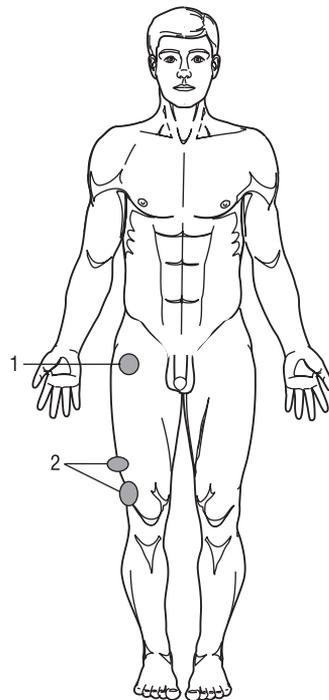


Fig. 27. TP of the rectus femoris (1) and vastus lateralis muscle (2)

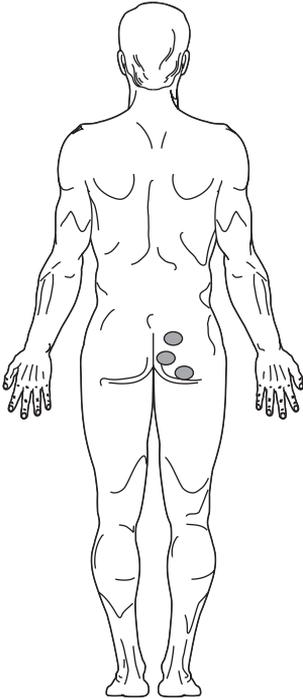


Fig. 28. TP of the gluteus maximus

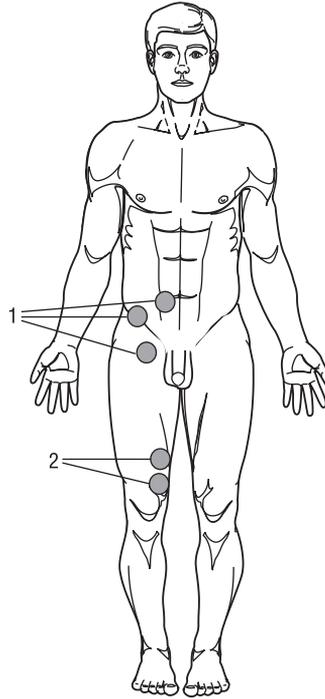


Fig. 29. TP of the iliopsoas muscle (1) and the quadriceps femoris (2)

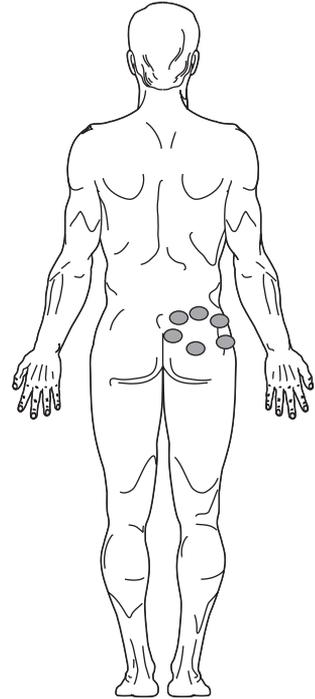


Fig. 30. TP of the piriform, medium and small gluteal muscles

The course of treatment includes 15 daily procedures, which it is advisable to start on Monday and to treat on working days, i.e., only three weeks.

It is also recommended to combine manual and laser therapy [Liev A.A., Apakidze T.V., 1992].

Method 3. Non-invasive laser blood lumination (NLBI)

Combined with methods 1 and 2, but not with procedure 5 (where already present). The parameters are shown in Table 33.

Table 33

Methods of NLBI patients with FM and with MFPS

Parameters	Value	Usage Notes
Laser wavelength, nm (spectrum)	635 (red)	NLBI-635
Laser operating mode	Pulse	–
Duration of light pulse, ns	100–150	–
Illumination power, W	30–40	Matrix emitting attachment ML-635-40 – 8 laser diodes

Table 33 cont'd

Parameters	Value	Usage Notes
Power density, W/cm ² (surface area 10cm ²)	3–4	NLBI-635
Frequency, Hz	80–150	–
Exposure per zone, minutes	2–5	–
Number of affected areas	1–2	The most commonly symmetric areas
Localization	On the projection of large blood vessels close to the area of the lesion	See in text
Method	Contact	Through the TMA
Number of procedures per course	12–15	Daily

Method 4. Integrated, combined, contact

The laser physiotherapeutic apparatus *Lasmik*, the matrix pulse IR laser illuminating attachment ML-904-80 (904nm wavelength, pulse mode, maximum power – 60–80W, frequency 80–150Hz), stable, contact through the TMA, sequentially into zones (Figure 31): 1 – 2 minutes; 2 – 1.5 minutes; 3 – 1.5 min; 4 – 1 minute. The course of treatment consists of 10–12 daily procedures.

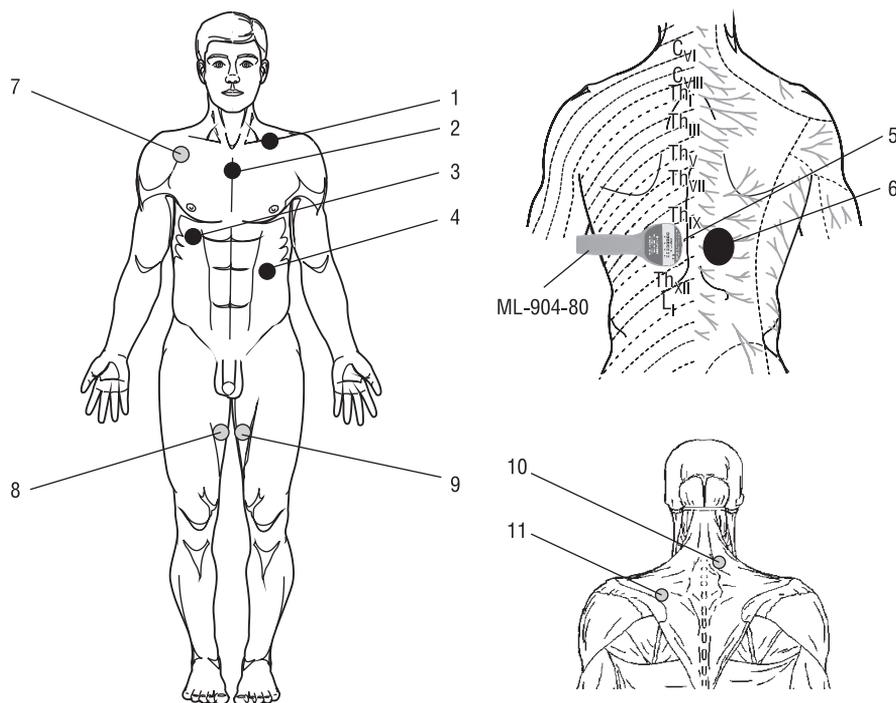


Fig. 31. Areas of influence of LILI in the treatment of patients with FM (combined method)

Combination of LT with massages, exercise therapy and manual therapy significantly increases the effectiveness of treatment. If necessary, the course of laser therapy is repeated after 3–4 weeks.

Method 5. Combined

1st stage

The laser physiotherapeutic apparatus Lasmik, the matrix pulse IR laser illuminating attachment ML-904-80 (904nm wavelength, pulse mode, maximum power – 60–80W, frequency 80–150Hz), stable, contact through the TMA, Sequentially into zones (Figure 31, Table 34): 1 – 2 minutes, 2 – 1.5 minutes, 3 – 1.5 minutes, 4 – 1 minutes; 3 – 5 minutes; 6 – 1 minute. ATTENTION! When exposed to zones 5 and 6, the ML-904-80 matrix laser illuminating attachment should be located perpendicular to the vertebral column.

Table 34

Parameters of the method of LT for patients with FM (combined method, zones 1–6)

Parameters	Value	Usage Notes
Laser wavelength, nm (spectrum)	904 (IR)	–
Laser operating mode	Pulse	–
Duration of light pulse, ns	100–150	–
Illumination power, W	60–80	Matrix emitting attachment ML-904 80 (8 pulsed IR-laser diodes)
Power density, W/cm ² (surface area 1cm ²)	6–8	–
Frequency, Hz	80–150	–
Exposure per zone, minutes	1.5–2	Zones 1–3
	1	Zones 4–6
Number of affected areas	6th	–
Localization	Zones 1–6, Fig. 31	–
Method	Contact	Through the TMA
Number of procedures per course	12–15	Daily

2nd stage

2–3 minutes after the end of the first stage, laser illumination with pulsed infrared laser illumination attachment LO-904-20 (one laser diode) with ZN-35 mirror attachment to the zones 7–9 for 1.5 minutes (Figure 31, Table 35).

Table 35

Parameters of the procedure for patients with FM (combined method, zones 7–9)

Parameters	Value	Usage Notes
Laser wavelength, nm (spectrum)	904 (IR)	–
Laser operating mode	Pulsed	–
Duration of light pulse, ns	100–150	–

Table 35 cont'd

Parameters	Value	Usage Notes
Illumination power, W	15–20	–
Power density, W/cm ² (surface area 1cm ²)	15–20	–
Frequency, Hz	80–150	–
Exposure per zone, minutes	1.5–2	–
Number of affected areas	3	–
Localization	Fig. 31, zones 7–9	–
Methodology	Contact-mirror	Through the mirror nozzle ZN-35
Number of procedures per course	12–15	Daily

3rd stage

Laser illumination of 1–2 of the most painful zones (TP), for example, 10 and 11 (Figure 31, Table 36).

Table 36

Parameters of the procedure for patients with FM (combined method, zones 10–11)

Parameters	Values	Usage Notes
Laser wavelength, nm (spectrum)	904 (IR)	–
Laser operating mode	Pulsed	–
Duration of light pulse, ns	100–150	–
Illumination power, W	15–20	–
Power density, W/cm ² (surface area 1cm ²)	15–20	–
Frequency, Hz	80–150	–
	3000–10.000	Perhaps the first 1–2 procedures
Exposure per zone, minutes	1	–
Number of affected areas	1–2	–
Localization	Zones10–11 (TP's)	Fig. 31 as an example
Methodology	Contact-mirror	Through the mirror nozzle ZN-35
Number of procedures per course	12–15	Daily

The effect on zones 8–11 (Figure 31), as one of the variants of the technique, can be carried out by illumination of an extremely high-frequency (EHF) range (wave length 5.6mm, power 1mW) [Brekhov E.I. et al., 2007; Moskvina S.V., Khadartsev A.A., 2016].

In the presence of such severe clinical symptoms as persistent sleep disturbance, anxiety disorders, tension headaches, fatigue, irritable bowel syndrome, treatment is performed alongside the consumption of antidepressants in minimal dosages.

Balneotherapy, massage and exercise therapy is carried out in the afternoon after a day, no earlier than three hours after the laser therapeutic procedure.

Cryotherapy during the course of laser therapy is excluded.

In addition, if necessary, vitamins (B1, B6, B12, C and folic acid) and trace elements (calcium, potassium, iron and magnesium) are prescribed.

The course of psychotherapy, especially at the initial stage, will also help to increase the effectiveness of treatment.

CONCLUSION

The book is, perhaps, the most complete review of studies and literature on the subject, to a much lesser extent the actual material (research results), objectively proving the effectiveness of laser therapy. It is possible that additional work is still to be done in this area, but many years of experience of a large number of practical doctors more than convincingly proves that laser therapy is often not equal in the treatment of patients of very different profiles.

The materials presented in the book far from exhaust the topic of pain management. In addition to the pain syndromes associated with the pathological processes of the soft tissues and partially the musculoskeletal system, there are many others that have their own peculiarities and hopefully are considered in detail in the relevant thematic publications. Many of the painful syndromes, such as the head, vertebrogenic and neuropathic pains of various origins, are considered in the context of studying the development of new methods of treating patients with a neurological profile. The pain syndrome, associated with dysfunction of the TMJ, is studied by dentists. The topic of oncology is special, where pain can be both a consequence of the disease itself and the result of specialized treatment, therefore, laser therapy is considered by specialists to be a method of rehabilitation.

Active work continues practically in all fields of medicine, and it is especially pleasing that not only in Russia, but all over the world, where laser therapy never used to be recognized and considered it to be a shamanism and an “alternative” treatment. Now it is continuing to develop with great enthusiasm. One of the motivating incentives for them is economic expediency, in the absence of competition (in the sense of methods of treatment) it is possible to provide patients with simple and inexpensive assistance, not only in terms of money, but also authority.

It may seem paradoxical, but it is the high efficiency and exceptionally low cost of treatment that is at present the main obstacles to the development of laser therapy in Russia. Unfortunately, according to normative documents, doctors do not “treat” patients, but provide services. From medicine, as one of the brightest examples of serving people with total dedication and self-sacrifice, when it is impossible to treat without the empathy and attention to a person, they have now done a “service.” For the statement of the simplest diagnosis, it is now almost automatically sent to the MRI, but there is no time to listen carefully or to examine the patient. Of course, it’s easier to buy an expensive device, kickback and relax (apologize to honest health organizers, which is most of them) and report on the work done, rather than to train and educate a good specialist.

Accordingly, many (fortunately, not all) now do not treat, but render a service, perceiving it as a business in its pure form: “Spend less, earn more.” With this approach, to treat (it is to treat the patient to forget about his problems for a long time), the more simple and inexpensive way, it is not profitable elementary, the effect needs a temporary, and “treatment” for life.

Among other things, laser therapy unites real doctors who want to help people, save them from suffering, treat them for real, and we are deeply convinced that there will be more specialists like this every day. In Russia, there are remarkable devices, a system of training, specialized journals, a constant exchange of information and achievements in the field of laser medicine, i.e., everything that is needed for the use of laser therapy in its practice.

APPENDIX 1

APPROVED METHODOLOGICAL RECOMMENDATIONS FOR THE APPLICATION OF LASER THERAPY

Intravenous laser therapy in the treatment of bronchial asthma: Methodological recommendations / Budaev B.B., Didkovskiy N.A., Korochkin I.M. et al. – M., 1990. – 8 p.

Intravascular laser illumination of blood in surgery and intensive care: Methodological recommendations / Kasymov A.K. et al. – Tashkent, 1989. – 14 p.

Helium-neon laser in the complex treatment of peptic ulcer of the stomach and duodenum: Methodical recommendations / Romanov G.A., Sazonov A.M. et al. – M., 1990. – 12 p.

Invasive methods of laser therapy in traumatology and orthopedics: Methodological recommendations / Berglezov M.A., Vyalko V.V., Ugnivenko V.I. – M., 1995. – 21 p.

Use of helium-neon laser illumination for the treatment of peptic ulcer of the stomach and duodenum: Methodological recommendations / Korochkin I.M. et al. – M., 1988. – 11 p.

The use of low-intensity helium-neon laser illumination in the treatment of secondary endothelial-epithelial dystrophy of the cornea: Methodical recommendations / Semenov A.D. et al. – M., 1987. – 7 p.

Use of low-energy laser and ultraviolet illumination in the treatment of non-specific lung diseases: Methodological recommendations / Malaya LT, Dzyublik A.Ya., Efimov V.E. et al. – Kiev, 1989. – 11 p.

Quantum therapy of diseases of the respiratory organs by illumination of low-energy helium-neon lasers by the method of compression of the illumination zone and the effect on autoblood and its subsequent reinfusion: Methodological recommendations / Chuchalin AG et al. – Tula, 1986. – 6 p.

Combined and complex treatment of lung, breast, esophagus and rectal cancer in conditions of application of plant adaptogens and laser illumination of blood (methodical recommendations). – M., 1996. – 15 p.

Complex rehabilitation of patients with congenital and acquired defects of the maxillofacial area: Methodological recommendations / Gerasimenko M.Y., Filatova E.V., Stuchilov V.A. et al. – M., 2003. – 7 p.

Complex treatment of purulent wounds with the use of immobilized trypsin on textile cellulose and synthetic matrices and laser illumination: Methodological recommendations / Tolstykh PI, Skobelkin O.K., Derbenev V.A. et al. – M., 1988. – 9 p.

Laser reflexotherapy of certain diseases of the nervous system: Methodological recommendations / Anischenko G.Y., Kochetkov V.D., Dallakyan I.G. et al. – M., 1985. – 15 p.

Laser therapy in the complex treatment of rheumatoid and infectious non-specific arthritis using domestic lasers such as LG-75 and ARZNI-210: Methodological recommendations / Mkheyanyan V.E., Igityan A.P., Illarionov V.E. et al. – Yerevan, 1988. – 13 p.

Laser therapy in treatment and rehabilitation and prophylactic programs: clinical recommendations / Gerasimenko M.Y., Geynits A.V., Moskvina S.V. et al. – M., 2015. – 80 p.

Laser therapy in the oncology clinic: Methodological recommendations / Pletnev S.D. – M., 1982. – 27 p.

Laser therapy of inflammatory and oncological diseases of soft tissues: Methodological recommendations / Dotsenko A.P., Grubnik V.V., Geshelin S.A. et al. – Odessa, 1988. – 19 p.

Laser therapy of the winged node with vasomotor rhinitis, trigeminal neuralgia and Sluder's syndrome: Methodical recommendations / Shuster M.A., Isaev V.I., Rechitsky V.I. – M., 1989. – 12 p.

Laser therapy of chronic purulent otitis media: Methodological recommendations / Mashenkin N.V., Loshchilov V.I., Tikhomirov V.V. et al. – Omsk, 1983. – 22 p.

Laser therapy of chronic psacid gastritis using a helium-neon laser: Methodical recommendations / Mansurov H.X., Barakaev S.B. – Dushanbe, 1989. – 14 p.

Laser installations of medical purpose. Physical principles and practical application: Methodological recommendations / Kortukov E.V., Kashuba V.A., Pavlov Y.K. – M., 1987. – 74 p.

Laser physiotherapeutic methods of treatment in ophthalmology: Methodological recommendations / Raevsky V.V., Uldanov V.G., Utelbaev T.G. et al. – Alma-Ata, 1987. – 18 p.

Laser therapy of inflammatory diseases of the upper respiratory tract in workers of the cotton mill and other industrial enterprises: Methodological recommendations / Psakhis B.I., Toropova L.A. – Krasnoyarsk, 1986. – 13 p.

Laser therapy of traumatologic and orthopedic diseases: Methodological recommendations / Ternovoi K.S., Chaplinsky V.V., Bulakh A.D. et al. – Kiev, 1982. – 14 p.

Laser therapy of musculoskeletal system overload in athletes: Methodological recommendations / Demyanov V.M., Anisimov A.I., Bely K.P. et al. – L., 1987. – 17 p.

Treatment of vasomotor rhinitis with helium-neon laser: Methodological recommendations / Soldatov I.B., Khrappo N.S., Korenchenko S.V., Kuzmin V.A. – M., 1985. – 17 p.

Treatment of helium-neon laser wounds, trophic ulcers and some orthopedic diseases: Methodological recommendations / Bogdanovich U.Y., Gordeeva A.I., Karimov M.G. et al. – Kazan, 1980. – 11 p.

Treatment of coronary heart disease with a helium-neon laser (acute myocardial infarction, HIBS): Methodological recommendations / Kipshidze N.N., Chapidze G.E., Bohua M.R. et al. – Tbilisi, 1987. – 13 p.

Treatment of periodontal disease and diseases of the oral mucosa using a helium-neon laser: Methodological recommendations / Prokhonchukov A.A., Alexandrov M.T., Bugai Y.P. – M., 1980. – 19 p.

Magnetolaser therapy of periodontal diseases: Methodical recommendations / Zazulevskaya S.Y. et al. – Alma-Ata, 1988. – 22 p.

Magnetolaser therapy in complex treatment and prevention of liver failure in mechanical jaundice using a semiconductor domestic device AMLT-01: Methodological recommendations / Briskin B.S. – M., 1989. – 11 p.

Method of using low-energy laser illumination for treating patients with various forms of chronic otitis media: Methodological recommendations / N.G. Sidolina. – M., 1990. – 9 p.

Methodical recommendations for the clinical application of the semiconductor two-channel laser therapeutic apparatus “Uley-2K” on gallium arsenide (wavelength 0.89 microns) / Dobkin V.G., Eliseenko V.I. et al. – M., 1993. – 74 p.

Low-intensity incoherent red light in complex treatment of peptic ulcer of stomach and duodenum: Methodical recommendations / Sazonov A.M., Romanov G.A., Karu T.Y. et al. – M., 1987. – 10 p.

Low-energy laser illumination in complex treatment of purulent surgical infections in patients with diabetes: Guidelines / Seliverstov D.V., Haussmann B.J., Puchkov K.V. et al. – Ryazan, 1992. – 22 p.

Low-energy laser illumination in complex treatment of complicated forms of acute purulent lung destruction in children: Methodological recommendations / Tsuman V.G., Shcherbina V.I., Mashkova A.E. et al. – M., 1992. – 12 p.

Exchange plasmapheresis with extracorporeal returned laser illumination of red cells in the treatment of suppurative lung disease, pleural and mediastinal disorders: Guidelines / Orlov S.V., White K.P., Y.D. Berezin et al. – St. Petersburg, 1992. – 12 p.

The use of intravascular laser illumination of blood in intensive care in children: Guidelines / E.V. Parshin, Ivaneev M.D. – M.–SPb., 1992. – 14 p.

Application of a helium-neon laser for the treatment of acute myocardial infarction: Methodological recommendations / Korochkin I.M., Kapustina G.M., Bohua M.R. et al. – M., 1989. – 20 p.

Application of helium-neon laser in the treatment of children with cicatricial stenosis of the larynx and trachea: Methodological recommendations / Nasedkin AN, Zenger VG, Shendalev VN. – M., 1989. – 14 p.

Application hemosorption and autotransfusion of ultraviolet illumination of blood in contaminated surgery in children: Guidelines / Levanovich VV – L., 1986. – 19 p.

Application of helium-neon laser illumination in surgical dentistry: Methodological recommendations / Prokhonchukov A.A., Alexandrov M.T., Bugai Y.P. – M., 1982. – 27 p.

The use of helium-neon laser in endodontics: Guidelines // MZ RSFSR, the Central Research Institute of Dentistry / Prokhonchukov A.A., Zhizhina N.A., A.A. Kunin et al. – M., 1983. – 19 p.

Application of helium-neon laser illumination for the treatment of patients with inflammatory diseases of the paranasal sinuses, auditory tube and middle ear: Methodical recommendations // Timirgaleev M.H., Shuster M.A., Stepanisheva N.I. et al. – M., 1987. – 12 p.

Application of infrared laser illumination in the treatment of hypertension: Methodological recommendations No. 96/61 // Builin V.A. et al. – M., 1996. – 20 p.

The use of combined helium-neon laser therapy in coronary heart disease: Methodological recommendations // Korochkin I.M., Kapustina G.M., Kartelishv A.V. et al. – M., 1989. – 16 p.

Application of concentrated sunlight in the treatment of patients with chronic bronchitis: Methodological recommendations // Zavalei Y.G., Zheleznikov I.G., Tkachenko N.I. et al. – Alma-Ata, 1987. – 10 p.

The use of laser in the treatment of Meniere's disease: Guidelines // Patyakina O.K., Nikolaev M.P., Popova T.V. et al. – M., 1986. – 11 p.

Application of a laser therapeutic device on gallium arsenide (wavelength 0.89 μm) ALT "Uzor" – electronics in medicine: Extended methodical recommendations // Skobelkin O.K., Litvin G.D., Eliseenko V.I. et al. – M., 1990. – 15 p.

The use of the laser therapeutic apparatus "Uzor" for the treatment of the pathology of the upper respiratory tract: Methodological recommendations // Nikolaev M.P., Psakhis B.I., Toropova L.A. et al. – M., 1989. – 9 p.

Application of laser methods of treatment in dentistry and surgery: Methodological recommendations // Pavlov A.F., Volkov V.E., Tsytkov V.E. et al. – Cheboksary, 1985. – 29 p.

Application of laser therapeutic devices "Lazmik" in sports medicine: Methodical recommendations // Kochetkov A.V., Moskvina S.V. – M., 2013. – 76 p.

The use of laser acupuncture in the complex treatment of hypotension in pregnant women: Methodological recommendations // Didia T.S. – Tbilisi, 1985. – 6 p.

Application of laser therapy in the clinic of internal diseases: Methodological recommendations // Shelygin S.I., Klodchenko N.N., Zarembo I.A. – Lugansk, 1990. – 17 p.

Application of low-intensity laser illumination for the treatment of chronic tonsillitis, chronic pharyngitis and rhinitis: Methodological recommendations // Preobrazhensky N.A., Klimova L.A., Bezchinskaya M.Y. et al. – M., 1988. – 10 p.

Application of low-energy laser illumination in pediatrics: Methodological recommendations // Koltsov V.A., Alexandrov M.T., Myaskovsky A.V. et al. – M., 1991. – 19 p.

Application of low-energy laser illumination in physiotherapy: Methodological recommendations // Danilova I.N., Minenkov A.A., Zubkova S.M. et al. – M., 1987. – 19 p.

Application of a semiconductor laser in oncology (manual for physicians). – M., 2001. – 12 p.

Application of semiconductor lasers in the complex treatment of postoperative intestinal paresis. Methodical recommendations // Skobelkin O.K., Builin V.A., Shveykin V.I., Sarantsev V.P. – M., 1990. – 17 p.

Application of a specialized dental treatment and diagnostic helium-neon laser device AFDL-1 in practical dentistry: Methodological recommendations // Bazhanov N.N., Alexandrov M.T., Arazashvili L.D. et al. – M., 1989. – 15 p.

Application of the therapeutic device “Uzor” for the treatment of pathology of the upper respiratory tract: Methodological recommendations // Nikolaev M.P. – M., 1989. – 9 p.

Application of the therapeutic pulsed infrared laser device “Helios-O1M” in medicine: Methodological recommendations // Kozlov V.I., Builin V.A., Stupin I.V. – M., 1994. – 20 p.

Prevention and treatment of dental caries, dentoalveolar anomalies and inflammatory purulent-destructive processes in the maxillofacial region using laser light: Methodological recommendations No. 99/93 // Prokhonchukov A.A., Zhizhina N.A., Kolesnik A.G. et al. – M., 2003. – 16 p.

Reflexotherapy of skin diseases using rays of helium-neon lasers: Methodological recommendations // Skripkin Y.K. et al. – M., 1987. – 9 p.

Modern Approach in the Treatment of Chronic Inflammatory Processes: Methodological Recommendations // Zhabko A.N., Molchanov I.V., Sannikov V.P. – Glazov, 2003. – 8 p.

Method of laser illumination with endoscopic photodynamic therapy of the primary cancer of hollow organs: Methodological recommendations. – M., 2001. – 6 p.

Ultraviolet laser illumination in a surgical clinic: Methodical recommendations // Krasilnikov D.M., Skobelkin O.K., Karpukhin O.Y. et al. – Kazan, 1991. – 13 p.

Ultraviolet illumination of autoblood in clinical practice: Methodological recommendations // Alekseev A.A., Ganelina I.E., Popov Y.V. et al. – M., 1985. – 20 p.

APPENDIX 2

**LASER MEDICAL TECHNOLOGIES REGISTERED
BY THE RUSSIAN MEDICAL AUTHORITIES
(ROSZDRAVNADZOR)**

Number	Date	Name	Organisation
FS № 2011/011	03.02.2011	Magnetolaser therapy in the rehabilitative treatment of patients with arterial hypertension with concomitant metabolic disorders	Research Institute of Medical Climatology and Rehabilitation, Vladivostok
FS № 2010/428	30.12.2010	The use of low-intensity intra-uratic hemolaser therapy in the rehabilitation of patients with autoimmune thyroiditis	FGU "RNC of Restorative Medicine and Balneology", Moscow
FS № 2010/362	07.10.2010	Laser therapy in the treatment of lumbar osteochondrosis and rehabilitation of patients after the operation of removal of the herniated intervertebral disc	Tomsk Scientific Research Institute of Balneology and Physiotherapy of FMBA
FS № 2010/344	21.09.2010	Subthreshold micropulse diode-laser coagulation in the treatment of diabetic macular edema	FGU "MNTK" Eye microsurgery. Acad. S.N. Fedorov"
FS № 2010/314	31.08.2010	The use of laser interstitial illumination in the puncture treatment of benign neoplasms of the breast	Establishment of the Russian Academy of Sciences "Central Clinical Hospital"
FS № 2010/292	06.08.2010	The method of treatment of cicatricial stenoses and cicatricial obliteration of the trachea with the use of bronchoproliferative laser interventions	St. Petersburg State Medical University. Acad. I.P. Pavlova"
FS № 2010/276	21.07.2010	Method of treatment of patients with abdominal obesity with the use of magnetolaser therapy in complex spa treatment	Federal State Institution "Pyatigorsk State Scientific Research Institute of Balneology FMBA"
FS № 2010/238	24.06.2010	Combined treatment of choroid melanoma with brachytherapy and transpupillary diodlaser thermotherapy	FGU "MNTK" Eye microsurgery. Acad. S.N. Fedorov"
FS № 2010/148	06.05.2010	Infrared laser keratoplasty in correction of hypermetropia, hypermetropic and mixed astigmatism	FGU "MNTK" Eye microsurgery. Acad. S.N. Fedorov"
FS № 2010/068	03.03.2010	Photodynamic therapy using laser medical Lazon-FT in the organ-preserving treatment of primary skin cancer and its relapses	FGU "Russian Scientific Center of Roentgenology"
FS № 2010/046	25.02.2010	Application of the hardware-software complex of electro-laser-magnetic therapy and color-impulse action of KAP-ELM-01-"Andro-Gin" in the treatment of gynecological diseases	CJSC "Yaninvest"
FS № 2010/037	24.02.2010	Application of the hardware-software complex of electro-laser-magnetic therapy and color-impulse action KAP-ELM-01-"Andro-Gin" in the treatment of urological diseases	CJSC "Yaninvest"

Number	Date	Name	Organisation
FS № 2009/391	25.11.2009	Complex correction of complications of multicomponent treatment of malignant tumors of various localizations with the use of ozone therapy and low-intensity laser illumination	FGU "Russian Scientific Center of Roentgenology"
FS № 2009/389	25.11.2009	Multicomponent programs for the treatment of cervical, vulvar, vaginal and rectal cancer in the radiosensitizing effect of local laser hyperthermia	FGU "Russian Scientific Center of Roentgenology"
FS № 2009/230	28.07.2009	The technology of differential laser and cryosurgical treatment of various forms of active retinopathy of prematurity	FGU "Moscow Research Institute of Eye Diseases. Helmholtz"
FS № 2009/200	23.07.2009	Low-intensity laser therapy in rehabilitation of cancer patients	FGU "Moscow Scientific Oncological Institute. P.A. Herzen"
FS № 2009/133	08.06.2009	The use of laser illumination with a wavelength of 0.94–0.98 microns in the treatment of peripheral veins	FGU "Treatment and Rehabilitation Center"
FS № 2009/071	09.04.2009	Panretinal laser coagulation with proliferative diabetic retinopathy	FGU "MNTK" Eye microsurgery named after academician S.N. Fedorov"
FS № 2008/271	03.12.2008	Transurethral contact laser ureterolithotripsy using the laser surgical complex Lazurit	LLC "Laser technologies in medicine"
FS № 2008/270	03.12.2008	Endoscopic treatment of unextended strictures of the urethra with the use of the laser surgical complex "Lazurite"	LLC "Laser technologies in medicine"
FS № 2008/263	25.11.2008	Method of laser extraction of cataracts	FGU "MNTK" Eye microsurgery named after academician S.N. Fedorov"
FS № 2008/262	25.11.2008	Method of laser treatment of patients with primary open-angle glaucoma	FGU "MNTK" Eye microsurgery named after academician S.N. Fedorov"
FS № 2008/236	07.11.2008	Laser and intensive CMT-therapy in early postoperative rehabilitation of reproductive function in patients with chronic nonspecific salpingo-oophoritis	FGU "Pyatigorsk State Scientific Research Institute of Balneology"
FS № 2008/234	07.11.2008	Combined use of endovascular laser therapy, acupuncture and laser puncture in correction of infertility in patients with chronic prostatitis	FGU "Pyatigorsk State Scientific Research Institute of Balneology"
FS № 2008/211	07.10.2008	Laser-induced interstitial hyperthermia in the treatment of nodular goiter	Central Clinical Hospital of the Russian Academy of Sciences
FS № 2008/155	23.07.2008	IOL implantation using IAG-laser anterior capsulorhexis in children with congenital cataracts	FGU "Moscow Research Institute of Eye Diseases named after Helmholtz"
FS № 2008/011	23.01.2008 – 23.01.2018	Application of diode laser scalpel in outpatient surgical stomatology	Federal State Institution "Central Research Institute of Dentistry and Maxillofacial Surgery"
FS-2007/229	12.12.2007 – 12.12.2017	Radon therapy and laser therapy in the autorotone mode in the treatment of patients with genital endometriosis	FGU "Pyatigorsk State Scientific Research Institute of Balneology"

Number	Date	Name	Organisation
FS-2007/198	08.10.2007 – 08.10.2017	Laser methods of rehabilitation of patients with consequences of mechanical eye trauma	FSI "Research Institute of Eye Diseases. Helmholtz"
FS-2007/181	14.08.2007 – 06.03.2011	Laser osteoperforation in the treatment of osteomyelitis	OOO Kvalitek
FS-2007/180	14.08.2007 – 06.03.2011	Application of semiconductor lasers in operative dermatology	OOO Kvalitek
FS-2007/173	09.08.2007 – 06.03.2011	Application of diode lasers in anorectal surgery	OOO Kvalitek
FS-2007/121u	26.06.2007 – 01.07.2014	Complex use of ultrasonic inhalations of mineral water "Lazarevskaya" and laser therapy in combination with balneotherapy in the treatment of children with primary arterial hypertension	FGU "Scientific Research Center of Balneology and Rehabilitation"
FS-2007/072u	24.04.2007 – 24.04.2017	Endolaryngeal microsurgery and holmium laser for respiratory papillomatosis in children	Moscow Regional Scientific Research Clinical Institute named after M.F. Vladimirovsky
FS-2007/059u	20.04.2007 – 20.04.2017	Laser therapy and laser surgery in Meiere's disease	Moscow Regional Scientific Research Clinical Institute named after M.F. Vladimirovsky
FS-2007/033	28.02.2007 – 28.02.2011	Use of laser radiation in operative otorhinolaryngology	OOO Kvalitek
FS-2007/032	28.02.2007 – 28.02.2011	Application of semiconductor lasers in operative gynecology	OOO Kvalitek
FS-2006/390u	29.12.2006 – 29.04.2012	The use of laser therapy in the bio-synchronized regime in patients with duodenal ulcer	Russian Scientific Center for Restorative Medicine and Balneology
FS-2006/389	29.12.2006 – 29.05.2010	Ultrasound therapy and laser radiation in the complex treatment of glaucoma	Moscow Regional Scientific Research Clinical Institute. M.F. Vladimirovsky
FS-2006/315	31.10.2006 – 12.04.2009	Laser puncture in the treatment of patients with neurological manifestations of osteochondrosis of the spine and rehabilitation of patients in the postoperative period of discectomy	Tomsk Scientific Research Institute of Balneology and Physiotherapy
FS-2006/254u	15.08.2006 – 08.07.2012	Treatment of patients with psoriasis and vitiligo with ultraviolet excimer laser radiation with a wavelength of 308 nm	Central Research Institute of Dermatology and Venereology
FS-2006/253u	15.08.2006 – 15.08.2016	The use of high-intensity diode laser radiation with a wavelength of 0.81 μm in the treatment of benign skin tumors	Central Research Institute of Dermatology and Venereology
FS-2006/156	07.08.2006 – 07.08.2016	Drinking mineral waters in combination with laser reflexotherapy in complex resort treatment of patients with diabetes mellitus, complicated by microangiopathy	Pyatigorsk State Scientific Research Institute of Balneology
FS-2006/069	05.05.2006 – 05.05.2016	Removal of intraocular foreign bodies injected into the membranes of the posterior segment of the eye, using laser methods of action	FSI "Research Institute of Eye Diseases. Helmholtz"
FS-2006/051u	11.04.2006 – 11.04.2016	The technology of using a laser scalpel with a wavelength of 1.06 microns in surgery difficult to access brain meningiogram	FSUE Novosibirsk Research Institute of Traumatology and Orthopedics

Number	Date	Name	Organisation
FS-2006/028	16.03.2006 – 16.06.2008	The use of the hardware-software complex of electro-laser-magnetic therapy and the color-impulse action of KAP-ELM-01 “Andro-Gin” in the treatment of proctologic diseases	CJSC “Yaninvest”
FS-2006/027	16.03.2006 – 16.06.2008	Application of the hardware-software complex of electro-laser-magnetic therapy and the color-impulse effect of KAP-ELM-01 “Andro-Gin” in the treatment of gynecological diseases	CJSC “Yaninvest”
FS-2006/026	16.03.2006 – 16.06.2008	Application of the hardware-software complex of electro-laser-magnetic therapy and the color-impulse action of KAP-ELM-01 “Andro-Gin” in the treatment of urological diseases	CJSC “Yaninvest”
FS-2006/025	10.03.2006 – 24.05.2011	Laser reconstruction of discs	Branch of the corporation “ARKYO MEDICAL, INC”
FS-2005/087	22.11.2005 – 22.11.2014	Application of high-energy lasers in operative otorhinolaryngology	OOO Russian Engineering Club
FS-2005/086	22.11.2005 – 22.11.2014	Application of CO2 laser in operative gynecology	OOO Russian Engineering Club
FS-2005/052	27.07.2005 – 27.07.2014	Laser therapy of psoriasis and vitiligo	Company KBV GmbH & Co. KG. KG
FS-2005/051	27.07.2005 – 27.07.2014	Laser epilation with devices ARION, MYDON and SINON	Company KBV GmbH & Co. KG. KG
FS-2005/050	27.07.2005 – 27.07.2014	Laser therapy of vascular and pigmented skin formations with laser devices ARION, MYDON and SINON	Company KBV GmbH & Co. KG. KG
FS-2005/049	27.07.2005 – 27.07.2014	Laser correction of aging skin with a laser system BURANE	Company KBV GmbH & Co. KG. KG
FS-2005/044	22.07.2005 – 22.07.2014	Treatment of vascular lesions of the skin with selective laser illumination	CJSC “Medical Optical Technologies”
FS-2005/043	22.07.2005 – 22.07.2014	Permanent removal of unwanted hair by laser illumination	CJSC “Medical Optical Technologies”
FS-2005/030	04.07.2005 – 04.07.2011	Laser septochondrocorrection	Corporation “ARKYO MEDICAL, INC”
FS-2005/012	07.06.2005 – 23.05.2013	Laser Hair Removal	Representation of Rosslyn Medical Limited
FS-2005/011	07.06.2005 – 07.04.2010	Selective photodestruction of a number of neoplasms and defects of the skin and mucous membranes with a laser medical device on copper vapor “Yakhroma-Med”	Physical Institute. P.N. Lebedev

APPENDIX 3

Moskvin S.V., Khadartsev A.A. Laser light – can they hurt? // Bulletin of new medical technologies. – 2016. – P. 23, No. 3. – P. 265–283.

LASER LIGHT – IS IT POSSIBLE TO HARM? (literature review)

S.V. MOSKVIN*, A.A. KHADARTSEV**

**FGBU “State Scientific Center of Laser Medicine of FMBA of Russia”, Moscow,
7652612@mail.ru, www.lazmik.ru*

***Medical Institute, Tula State University,
ul. Boldina, 128, Tula, 300012, Russia*

Abstract. It is widely known that laser therapy is a highly effective physiotherapy method for treating patients with various diseases. However, among the patients and some of the medical staff, there are unfounded myths about the so-called “harmfulness” of laser light. Literary reviews, analysis of scientific data and many years of practical experience demonstrates clearly and quite convincingly that low-intensity (low-energy) laser light used in modern physiotherapy is absolutely safe. It does not have teratogenic, mutagenic and carcinogenic properties, but on the contrary, it provides protection of a living organism from the most diverse pathogenic factors of a chemical or physical nature.

Key words: low-intensity laser illumination, protector properties, teratogenic, mutagenic and carcinogenic effect.

LASER LIGHT – IS IT POSSIBLE TO HARM?

S.V. MOSKVIN*, A.A. KHADARTSEV**

**“State Research Center of Laser Medicine FMBA of Russia”,
Moscow, 7652612@mail.ru, www.lazmik.ru*

***Medical Institute, Tula State University,
ul. Boldin, 128, Tula, 300012, Russia*

Abstract. It is a widely known fact that laser therapy is a highly effective physiotherapeutic method of treating patients with various conditions. However, many unjustified myths have been spreading among patients and some of the medical staff about the supposed “harm” caused by laser light therapy, despite the various literary studies published, thorough analysis of scientific evidence and years of practical experience clearly and convincingly demonstrating that low intensity (low energy) laser light used in modern physical therapy is entirely safe. It has no teratogenic, mutagenic

and carcinogenic properties. Moreover, it protects the cells in the human body from a wide variety of pathogenic factors – whether they are chemical or physical in nature.

Key words: the protective properties of low-intensity laser radiation, teratogenic, mutagenic and carcinogenic effects.

Introduction. Laser therapy (LT) became a prominent part of modern Russian medicine a long time ago. However, only recently (since the early 2000's) had there begun to be a rise of research and introductory use of this medical procedure in Western Europe and the United States, where the very possibility of using low-intensity lasers (LLLT) on biological beings had been denied and/or banned previously. The reasons for the almost universal recognitions of the various advantages are obvious – this method is simple, inexpensive, safe and comfortable to use, and has shown virtually no contraindications. Most importantly, this is the exceptional and efficient use of modern technology, developed by hundreds of Russian scientists and clinicians, based on the thorough knowledge and understanding of the (therapeutic) biological mechanisms of LLLT [56, 57]. The basis of laser therapy lies in the well-known healing properties of LLLT. A number of authors also use the term laser light (LS), which is quite acceptable in its therapeutic use, especially in ophthalmology [61]. However, many unjustified myths have been spreading among patients and some of the medical staff about the supposed “harm” caused by laser light therapy, the supposed teratogenic, mutagenic and carcinogenic effects it has on the human body. These unjustified fears have been caused by a number of subjective and objective reasons. Primarily, it can be traced to the psychological stress on impressionable patients provided with incorrectly used terminology. Obviously, if you “irradiate” something in “doses”, and at the same time “stimulate” it (as many people have begun to say), then any normal person would begin to have doubts about the safety of this method. People are obviously scared of laser beams, and this needs to be taken into consideration. Words can cure, but they can also do damage. You can evidently see this effect in the neurological ward, in patients with chronic ischemic changes in the brain. Their first laser therapy session is preferably carried out with a switched off device to provide a placebo effect. It is evident that an average of 15% of these patients can be observed to have negative side effects – such as dizziness, weakness, low blood pressure etc. – even though they've been treated by a switched off machine. According to many experts, they believe that these negative side effects are caused by a well-known number of “laser-irradiative hazards” [55, 56]. Another example of this can be found in an article published recently in a well-known scientific journal, the publishers autocratically changed the words “exposed to light” – used by the original authors – to “radiate light”, motivated solely by the fact that “people were used to saying it like that”. It is hardly appropriate to do this, due to the term “light exposure” already being approved by and used in official medical and scientific documents [46]. The emergence of these various phobias in relation to laser light is, of course, straightforward ignorance. Unfortunately, during the various training courses provided in this field, there may be incorrect information provided regarding the indications and contraindications of laser therapy conduct. There also appears to be a lack of education in regards to the patients, who are often unaware of

the safety of the method. This article will attempt to analyse some of the data provided in various scientific studies throughout the years, as well as critically review a number of “negative” articles published about this topic. The emergence of these various myths about the dangers can mainly be attributed to one thing: competitors. Competitors are likely afraid of the effectiveness of this method of treatment. Patients who undergo proper treatment using laser light therapy will likely no longer need the aid of various drugs or medicines.

Applications and features of Laser light:

1. In a normal light emitting diode (LED), flashlight, light bulb or the sun, the light is not coherent (wavelengths are all varying frequencies). Laser light, however, is different. Its spectrum is of different width, or a different in the degree of spatial or temporal coherence. The laser can only generate photons from one type of energy source, or one wavelength – which is its main distinguishing feature – meaning the light is monochromatic and coherent. Broad, incoherent light sources (e.g. LED, lamps, etc.) emit photons with different energies, and the light is polychromatic. It is reminiscent of science experiments with prisms creating the natural phenomenon of the rainbow. Other than that, there are no more specific distinguishing features. This particular laser light is electromagnetic radiation within the visual range, and does not emit radiation as some may believe. Laser therapy often uses multiple different spectral bands: near the ultraviolet wavelength (between 365 and 405 nm), the green wavelength (525nm), the red wavelength (635nm) and the infrared wavelength (890nm and 904nm). Of course, the powerful UV laser light (205 nm) can damage the DNA of cells [115], but it is not due to the coherence, but rather the wavelength (spectrum). This is where it would be beneficial to avoid comparing the incomparable, which is often done in scientific articles, where they compare “laser” and “ultraviolet” light sources.

2. The recently approved (in Russia, as well as the World Association of Laser Therapy [WALT]) clinical guidelines have urgently prompted for all users of laser light to clearly outline and specify all parameters of use during scientific or laser therapy procedures. They require the following information: wavelength mode (continuous, modulated or pulsing) or average pulsing power, frequency of pulsing lasers and the illumination of a single zone to the light. It is also important to note the area of illumination or the method – contact with a reflective mirror head, Intravenous laser illumination of the blood (ILIB), acupuncture, etc., the localization of laser illumination (area), the number of procedures during the treatment course. This is extremely important to note as the patient cannot be harmed. Careless or inaccurate specifications of the points above may lead to an effect opposite to the one desired.

3. It is also important to take into account the fact that laser light may not only stimulate, but may also inhibit the biological (physiological and biochemical) processes. It’s important to focus on the reactions of the body in relation to the above laser illumination parameters, and when setting the optimal conditions for each case, the laser light normalises disturbances, which, to some extent have a place in the biological system, whether it is a single cell, cell structure, tissue, body, animal or human organism. At present, this process can be referred to by the term laser “bio-modulation”

[56, 57]. If the required parameters are not specified during the use of the laser light, the effect of the treatment may worsen the situation, and may lead to the development of pathological processes.

4. What are the “low-intensity” lasers that are used for bio-modulation and physiotherapy? It is imperative to understand that to classify this, you not only need to know the intensity – which in this case the lasers are from 1 to 200 mW in continuous mode (depending on the method and wavelength used), from 5 to 100W in pulsed mode (with a single laser, with a pulse duration of 100 nanoseconds and a frequency of 80 to 10.000Hz) – but also the time of illumination on a single zone, which should not exceed 5 minutes (with the exception of ILIB). By multiplying the power and exposure time, we obtain the energy that is measured in Watt*sec or joules (J), so it is more correct to refer to is as low-intensity laser light, and the device that produces low-intensity laser light. Laser light is completely safe and harmless, as well as being very useful. Laser therapy is also safe and useful, but only under strict conditions and the specified guidelines set when working with this method of treatment. If these guidelines are not followed correctly and laser therapy is used carelessly, it may indeed cause harm. However, when applied correctly, this method should not be associated with causing potential harm to the patient. This can be compared to something as simple as water – vital for life and for a human, but people can still drown if they are careless around it. It must be reiterated that only low-intensity laser light is being discussed, while it is the very powerful (surgical) lasers that may cause burns if they are used incorrectly. And when you’re speaking of a patient, it is important to note that in some cases, the word “laser” itself may cause harm, even though there is an absence of radiation (people have a phobia to the word). However, the discussion will continue only about the facts of the objective effect of laser light on biological systems. Let’s consider a few different directions and attempt to answer one of the most important questions, as to whether laser light has teratogenic, mutagenic or carcinogenic effects? Let’s bring to light a number of studies that have conclusively proven that low-intensity laser light is not only safe, but it has protective properties against a wide variety of pathogenic factors (radiation, toxins and UV light).

Laser therapy is not teratogenic. Teratogenicity – the ability for physical, chemical or biological agents to cause disturbances in the process of embryogenesis, leading to the occurrence of congenital malformations in humans or animals. This concept is closely associated with mutation and is a permanent genotype conversion that occurs under the influence of external or internal environmental influences, which can be inherited by the offspring of the cell or organism. Laser light therapy is not on any list of teratogenic factors and it is impossible to establish it as a “potentially” negatively impacting mechanism [4, 12]. The answer to the question regarding the likelihood of laser light having a negative impact on foetuses, or the abnormal development in embryogenesis is based on the available scientific evidence and the biological action of laser light at a cellular level, and therefore is negative. At this point in time no one has provided justifiable evidence, even though theoretically and hypothetically the use of laser light leads to the loss of DNA information, and as a result, a negative effect. In the case of a number of known physical, chemical and biological teratogens, the ne-

gative effects are well established. For example, the ionizing radiation causes somatic mutation of foetal cells in the early stages of its formation through the modification of the nucleotide sequence in the DNA molecule. The changing of the hereditary code is often accompanied by synthesis of defective proteins (such as enzymes, structural proteins), which can lead to functional disorders which are often not suitable for life, leading to miscarriages. The explanation of these damaging mechanisms are found within the physical factors of teratogenicity: radiation (not light!), which is ionized, i.e. its energy, its corresponding frequency (measured in eV, and is not to be confused with the energy associated with level of radiation!), and is enough to dislodge electrons upon absorption of the molecule by changing its properties (chemical formula). Like the ionizing radiation, these chemical pathogenic agents may lead to damage or tearing during chromosome fusion (unable to split during mitosis). It is quite obvious that laser light is not ionizing, and therefore cannot cause disturbances in the structure of DNA and the mechanisms of mitosis. Many chemical agents have the ability to disrupt protein synthesis by blocking the processes of replication: DNA synthesis, transcription and translation (protein synthesis itself). Some related materials may include some antibiotics and cytostatic drugs. For the most part, these substances may lead directly to foetal death. Malformations are observed much less frequently. Similar reactions occur as a result of infection, for example, certain types of viruses. But in relation to low-intensity lasers, it certainly only enhances the synthesis of both RNA and DNA, without interfering with species variation [39, 106, 107]. Violation of the permeability of the cell membrane in the embryo may result in the death of the embryo, as well as impairment of eyes, brain and limbs. It is presumed that teratogenic-based substances such as dimethyl sulfoxide and vitamin A use this mechanism. However, research has proven that low-intensity laser stabilises the permeability of membranes, as well as improving cell adhesion and accelerates the transmembrane ion transport [105, 110]. It also increases cellular cAMP levels [40, 111]. Violation of the energy exchange may lead to teratogenesis or foetal death. The reason for this can be due to the prevention of glycolysis, damage of the citric acid cycle (iodine and fluoro acetate, 6-amino nicotinamide), blockage of the electron transport system and the uncoupling of oxidation and phosphorylation of (cyanide, dinitrophenyl). But once again, this does not refer to laser light, which is known to contribute to the significant enhancement of metabolism (energy) within the cells, as well as enhance protein synthesis in cells [101, 102, 108, 109]. What is absolutely incredible, it to suspect laser light within the system to have the same negative impact that other substances have, those that block the flow of essential elements to the mother and foetus. When talking about low-intensity lasers, it is only possible to speak of the extremely beneficial effect, that which exerts a protective effect on the body of the future mother and the foetus. This is why laser therapy is widely used in obstetrics for prophylactic purposes [14, 20, 36–38, 73]. Laser therapy falls within the standard of medical assistance used in obstetrics and gynaecology [66]. Moreover, the intensive care unit (ICU) for pregnant and postpartum women must be equipped with laser therapy devices [67]. It is very doubtful, that a method that has been officially allowed and effectively used for treatment for many years could provide even the smallest of negative effects on any levels (cellular or otherwise). However,

we cannot ignore the study – albeit only a single study – that has alleged that laser light has a negative impact on embryos. In particular, bird embryos. Some researchers suggest that the mesonephric chickens at the 7th–15th day of incubation as a result of low-intensity laser light illumination (633 nm, 5 mW) will have changes similar to those observed in chronic interstitial nephritis [91], histological and histochemical changes in the tissues of the tongue, belly, ovaries and kidney in the endo and mesoderm, typical of teratogenicity [119], hyperplasia of basal epithelial cells of buccal salivary glands, followed by erythrocyte infiltration [120]. However, firstly, it is necessary to bring to attention the fact that the laser light illumination was carried out through an artificially made hole in the egg shell, and this itself can trigger the emergence of various defects. Secondly, the publication date of this article coincides with the most active “anti-laser” campaign period of time. The results are likely rigged, due to the fact that literally thousands of other studies on the effects of low-intensity lasers on the eggs of various birds (chickens, geese, quail, turkeys etc.) did not show any negative results, but rather the opposite [6, 9, 21, 27, 34, 41, 42, 53, 64, 72, 81, 89]. Still, many are continuing to attempt to discredit laser therapy. For example, study [54] allegedly shows that exposure to laser light reduces the hatchability of goose and chicken eggs. However, the data provided seriously conflicts with the results from thousands of other similar studies. Even more, the authors refer to Professor A. B. Budagovsky, who has in fact stated that results are very positive – the exact opposite of the data provided by this study. His statements also uphold the statements in previous articles written by the same authors [69]. So why have they “all of a sudden” changed their minds? There are a number of studies and thousands of publications by different authors from dozens of different countries – which have been conducted in similar circumstances – which deal with the beneficial use of laser light on eggs in the poultry industry. These articles recommend the use of laser technology on an industrial scale. The lack of negative consequences relating to low-intensity laser usage with animals – including the eggs of various birds – is indirectly confirmed by the active introduction of laser technology in the Russian livestock industry, as well the publication of textbooks for students in high profile institutions [17–19]. An example of one recent study – which demonstrated that laser illumination of chicken eggs before incubation, as well as illumination on the 6th, 12th and 18th day using the laser therapy device “Matrix” (wavelength 635 nm, continuous mode, the power density on the surface eggs 20 mW /cm², exposure 3 min), does not cause any adverse side effects, but significantly improves biochemical parameters of the blood during foetal ontogenesis of the bird [2]:

Total calcium content in the blood is increased by 0.21 mmol/l in 6-day old embryos, by 0.55 mmol/l at 12 days of age, by 0.84 mmol/l at 18 days of age and by 1.15 mmol/l by the end of foetal ontogenetic life, so with age and the number of times illumination occurred the differences in the total calcium content in the blood between the control and experimental group is significant.

There was significantly more inorganic phosphate in the blood plasma of the experimental groups (which were exposed to laser) control group – by 0.27 mmol/l at one day and by 0.36mmol/l at 12 days of age.

The eggs exposed to low-intensity laser light were positively affected. From 6 to 12 days of development of blood alkaline reserve was 3.30 volume percent of carbon dioxide.

The level of carotene in the plasma in the experimental groups were almost equal until the 6th day of incubation – 2.94–3.14 mmol/l. However, as the embryos aged and after the number of laser illuminations, the difference between the control and the experimental groups increased and became 0.67–0.45 mmol/l at 12 days, 1.19–0.63 mmol/l at 18 days at the end of embryonic period of development – 0.53–0.44 mmol/l, with the most active phase of synthesis of carotene from the 12th to the 18th day of development of the embryo.

At the same time, the illumination of the eggs with a non-coherent lamp DNESG-500, with a similar wavelength (maximum range of 640.3 nm in the range of 630–650 nm) and similar energy parameters caused significantly less effects, in some cases none at all [2]. From the above information, it can confidently be concluded that low-intensity laser therapy does not contain any teratogenic properties at all.

Low-intensity laser therapy does not cause mutations to occur. Due to significant differences between materials and methods, as well as the findings, it can be considered to divide the discussion of the results of relevant studies carried out with plants and animals. It has been a well-known fact for a long time, that “processing” seedlings before they have been planted – i.e. Laser light exposure to seedlings – increases germination, yield and plant resistance to severe weather conditions, therefore improving the overall quality of the plants. This significant feature of laser light has been widely used in plant breeding for quite a long time [1, 8, 11, 45, 59, 60, 80, 85, 118]. More importantly, the response to laser treatment means that the qualitative properties of the exposed seeds will grow into improved plants. The reasons for this phenomenon – as well as the mechanisms underlying this incredibly positive reaction to laser illumination – still remains a mystery. The specific biological action of low-intensity laser therapy causes greater gene expression than normal environmental factors. As a result, there are modifications which occur, going beyond limits of what the control group of seeds can do [22, 29, 30, 86]. The findings also concluded another fact, that which the beneficial properties acquired by the seeds through “laser stimulation” remained until at least the third generation (minimum) [15, 118]. But it would be quite wrong to jump to the conclusion that this is a variation of “genetic engineering”, allowing you to create “Genetically Modified Organisms (GMO’s)”, even though many of the professionals involved in plant breeding like to call it “laser mutation”. It is, however, incorrect and unacceptable to use this terminology and to claim such findings, since no one has yet revealed the presence of changes within the plant genome. For most professionals is quite obvious that the laser light in the visible wavelength spectrum is not a mutagenic factor, and its application is not related to the genetic modification of plants as such, but rather is epigenetic mechanism of long-term memory, “the stimulus” effect. This phenomenon is accepted as “laser mutation”, even though it is completely different processes, which lead to the same results [10]. Let’s examine the results in detail. It should be reiterated that epigenetic changes in gene expression are not due to the changes in genetic information (mutations), but occur due to the modification

of the level of gene expression, e.g. their transcription or translation process. One of the most studied types of epigenetic regulation is the DNA methylation with the help of protein – DNA methyltransferase – which leads to the temporary inactivation of methylated genes (depending on the environmental factors). However, since the structure of the DNA molecules is not changed, this exception cannot be considered a true example of transference of information from the protein to DNA. The methylation is carried out enzymatically in the first few minutes after DNA replication, i.e., post replicative [93]. Even though it is a stable and inheritable modification, generally it is a reversible modification when exposed to de-methylating agents or enzymes, and therefore fundamentally differs from DNA mutations. Apparently, it appeared during the process of evolution as a way to limit the activity of unwanted “extra” genes in vertebrates – known as a functional reorientation methylation system. If all invertebrates aim to suppress the formation or activity of potentially dangerous DNA sequences (such as viruses and transposons), but in vertebrates, it serves as a more stable repression of endogenous genes (genes inactivated by the X-chromosome, imprinted genes and tissue-specific genes). Profile methylation, strongly influenced by the functional state of the gene, and is stably transferred in a series of cell generations. From this point of view, for organisms with a long life and intensive tissue regeneration (vertebrates, plants), this reliable system of epigenetic inheritance (such as DNA methylation) is vital. The specificity and the functional significance of the enzymatic DNA methylation has remained unknown for many years. In addition, it was a common belief until recently that these “minor” bases do not play any roles in the structure nor the function of DNA itself. Often, the “compelling” argument for such representations often uses the favourite subject among classic genetics – *Drosophila melanogaster*. This gave many people – including Nobel prize winner W. Gilbert – the motivation to prove to people that because drosophila lives without DNA methylation, this means that this modification is not essential in the life of eukaryotic organisms. However, it has now been firmly proven, that methylated DNA in *Drosophila* and the modification of the genome is important for the development of an insect, and DNA methyltransferase activity is clearly detected in the early stages of animal development [97, 123]. The mention of drosophila flies in the context of epigenetics relates to the data found by one research group, the results of laser illumination to the fruit fly infrared pulsed low-intensity laser therapy [16, 31, 84, 88], were perceived by many as almost a direct and obvious threat to the hereditary apparatus of man as a result of laser therapy. Now, it is understood, that this is not in fact true. There are no doubts in the fact that the methylation of DNA, the modification of histones and selective gene silencing by small RNA molecules play a very important role in the life of the cell and the organism. According to the bulletin of biotechnology from the Massachusetts Institute of Technology (USA), epigenetics has been listed as one of the top ten new technologies which could change the world within the next decade. Without knowledge of epigenetics, there is no possibility of developing and improving cellular technologies (stem cells), giving reliable diagnosis’, preventing and treating of various forms of cancer or preventing premature aging. Epigenetics is the basis of finding effective ways to fight many infectious (including viral) diseases in animals and plants, as it undoubtedly will. It is also the key to im-

proving the quality of crops in different cultures, as well as improving productivity in different breeds of animals [13]. When talking about the animal kingdom, there is data that shows the influence of helio-meteorological factors on genetics. For example, the coincidence of the 27-day cycle solar activity (the period of time that the Sun revolves around its axis), with the number of births of lambs in a period of 150 days and the weight of young lambs. If fertilization takes place in a period of increased solar activity of 1–3 days (give or take), then offspring is larger, and the head is heavier by an average of 1.2–1.5 kg than when fertilization occurs during low solar activity [52]. In other words, epigenetics works within the natural conditions for living things. Based on the above information, we can clearly conclude that low intensity (low-energy) lasers does not and cannot cause mutations.

Low-intensity laser therapy does not stimulate cancer cells. This topic has been widely discussed, and for professionals, this is a well-known fact. Back in the 1960's and 1970's, it had been proved: laser light does not have any oncogenic effects. It does not stimulate the development of cancer and metastasis, but instead, it has been proven to suppress. Thousands of studies have been performed in dozens of countries – both among animals [70] and in and in the clinic [32] – and have proven this as a fact. Laser light has actively (and very successfully) been used in clinical oncology. Physical therapy – including laser therapy – is the basis for the rehabilitation of cancer patients [23, 24], laser exposure has also been used to prevent complications after the primary treatment of cancer patients (surgical removal of tumours, radiotherapy, chemotherapy, photodynamic therapy) for many years [25, 26, 82, 83]. The Federal State University, the “Moscow Research Oncological Institute. Named by Herzen” in Moscow, Russia registered a new medical technology: № 2009/200 “Low-Level Laser Therapy in the rehabilitation of cancer patients” on the 23.07.2009. Quite a lot of guidelines had been developed the time of the Soviet Union [43, 47, 48]. Laser therapy is part of standard medical rehabilitation. Even more so, in the management of cancer patients [66, 77], laser therapeutic prevention of early radiation reactions has been given the leading position in gynaecological oncology [78]. There is a fairly large amount of scientific and practical experience to confidently recommend radiotherapy to cancer patients [32, 49–51, 74, 79, 82, 83, 96], including children [7, 68, 92]. A promising area of research is considered to be a combination of laser action with the introduction of metal nanoparticles [75, 103]. Moreover, low-intensity laser therapy is perfectly safe for cancer patients, and does not stimulate the growth of tumours, and medical professionals from other countries agree [112, 113, 116, 121]. Only in the last few years have English language journals published hundreds of papers speaking about the use of radiotherapy in oncology practice: mucositis and other complications of chemotherapy and radiation therapy [87, 90, 94, 99, 46, 114, 117, 122] post-mastectomy and pain syndromes [3, 71, 77], lymphedema [98] and others. It is safe to conclude that there are a lot of arguments in favour of this well-known and quite obvious fact – low-intensity laser therapy does not cause cancer in people, and radiation therapy has been used successfully in the complex treatment and rehabilitation of cancer patients.

Protective properties of Low-intensity laser therapy. The protective properties of low-intensity laser therapy are well-known; they help protect living organisms from

the harmful influence of various pathogenic factors. The properties of laser light known to be very radio-protective. For example, a recent study shows that the illumination using low-intensity laser therapy (940 nm) significantly prolongs the life of mice irradiated with a lethal dose of radiation [100]. This property of laser light is widely used in oncology practice. Early radiation reactions can serve as a prerequisite for late radiation damage, which is more painful for patients than the general gynaecological cancer disease (for example, rectovaginal fistulas and recto-vesical, osteoradionecrosis, transverse myelitis). Laser therapy can be used as a method of early prevention of radiation reactions in gynaecological cancer patients to minimize the frequency and severity of complications from pelvic organs, without impacting negatively on the results of basic treatment. This significantly improves the quality of life for patients [78]. There have been many successful experiments on animals, as well as clinical trials, that have shown the effectiveness of laser therapy on the effects of radiation damage: laser energy with certain parameters is an effective anti-mutagenic factor; it stimulates the restoration of damaged chromosomes caused by ionizing radiation, as well as by chemical mutagens. It restores immunity, bone marrow function, microcirculation in vital organs, increases performance and quality of life. Radio-protective properties of low-intensity laser therapy are similar to an effect of the well-known and commonly used chemical radio-protectors [58]. In an experimentally induced liver damage using chemical, radioactive or mechanical factors, it was found that if during this time, the liver is exposed to laser light (633 nm, 1–1.5 J/cm² in one procedure), the process of regeneration begins to occur. This leads to the normalisation of structural and cytochemical indicators, its reduces of severity of the degenerative changes and the healing process of the damaged mechanical organ begins [33]. It is shown that a course of laser therapy conducted to the offspring of the radiation-affected parents (experiment conducted on white rats), has a positive effect on the organization of their reproductive apparatus. There has also been an identified radio-protective effect of the effect of lasers on animal organisms to a single X-ray and gamma-radiation [63]. Research on the morphological, physiological and biochemical parameters of cardiovascular, endocrine and nervous systems of the body in conditions of interaction of ionizing and laser illumination allows us to conclude the opposite direction of their influence on the course of many processes that take place at different levels of the organism.

Thus, ionizing radiation slows down, but laser illumination enhances:

1. Chromatin recovering, or damaged DNA repair;
2. The biosynthesis of the antioxidant system;
3. The biosynthesis of neurotransmitters;
4. The repair of enzymes begin. They begin to form, as well as various types of enzyme-rich substances begin to synthesise
5. The synthesis of phospholipids, forming cell membranes;
6. The process of reparative regeneration occurs;
7. The proliferation of cellular systems;
8. Microcirculation;
9. The sympathetic activity of the autonomic nervous system;

10. The speed of nerve impulses and intra-cardiac conduction

11. The neuro-secretion process.

Of course, this list can easily be continued. However, the discovery directly opposing the laser illumination and harsh ionizing radiation, at least in relation to these processes, it gives some the right to assume the possibility of using the laser illumination as a factor that slows down and even stops the unfolding of post-radiation effects. The light beams generated by the lasers have shown to have complete anti-radiation effects, and can be used to protect against radiative injury, or against any changes which have occurred post-radiation exposure in the body [62]. It has been shown that in the period of 10 years following the Chernobyl accident, the number of patients with chronic autoimmune thyroiditis had increased by 10 times in radiation-affected areas [35]. The formation of this disease occurs due to a deficiency of suppressor T-cells, which then leads to the mutation of forbidden clones of T-lymphocytes. This then causes a local cellular reaction, and the formation of lymphocytic infiltration. More antigens then attract B-cells, producing more antibodies. This facilitates the subsequent proliferation of connective tissue, and a decrease in the functional activity of the gland. Medical and surgical treatment is often ineffective. A histological examination of the thyroid and thymus glands 2 weeks after a course of laser therapy (wavelength 890 nm, pulse power 8–10 W, frequency 80 Hz, exposure to the projection of the thyroid gland for 30secs, over-the-vein illumination of the blood – 2 minutes, daily for 7 days) showed signs of declining auto-aggression, the morphological equivalent being the degree of lymphoplasmacytic infiltration. There was a trend toward the normalization of functional activity of the thyroid epithelium of the thyroid gland, during the process of activation of the reparative regeneration processes. In the thymus, increased lympho-cytopoiesis revealed an activation of epithelial-reticulopoesis, while slowing the involute processes. This, and other studies have formed the basis for effective methods of laser therapy in patients with autoimmune thyroiditis [5, 28, 44]. Much more can be brought to scientific publications, proving that low-energy laser light boasts protective properties against ionizing radiation, as well as a number of other physical and chemical pathological factors, as well as the understanding the clear reasons for the use of low-intensity laser therapy in modern medical practice, due to the valuable features it entails.

Conclusion. This very concise review of various studies, clearly and convincingly demonstrates that low intensity (low energy) laser light used in modern physiotherapy – with all basic rules and regulations adhered to – is absolutely safe. It has no teratogenic, mutagenic or carcinogenic properties, and conversely protects the living body from a wide variety of external pathogens, whether chemical or physical in nature.

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LIST OF ACRONYMS

LTA	– laser therapeutic apparatus
AOC	– antioxidant system
ROS	– reactive oxygen species
AX	– acetylcholine
AChE	– acetylcholinesterase
Bu	– base unit (laser therapeutic apparatus)
BA	– biological (biomodulating) action
PZ	– painful zones
VAS	– visual analogue scale
ILBI	– intravenous laser blood illumination
ANS	– autonomic nervous system
TMJ	– temporomandibular joint
GABA	– γ -aminobutyric acid
HeNe laser	– helium-neon laser
IR	– infrared (range, spectrum)
IL	– interleukin
EHF	– extremely high-frequency (range)
MSS	– musculoskeletal system
CRPS	– complex regional pain syndrome
LD	– laser diodes
LDH	– lactate dehydrogenase
LT	– laser therapy
LUVBI	– laser ultraviolet blood illumination
MDA	– malonic dialdehyde
MLT	– magnetolaser therapy
MFPS	– myofascial pain syndrome
NDG	– neurodynamic generator
LILI	– low-intensity laser illumination
NLBI	– non-invasive (supra-vascular, over-the-top, percutaneous, transcutaneous) laser blood illumination
NSAID's	– non-steroidal anti-inflammatory drugs
CCA	– common carotid artery
VA	– vertebral artery

PTN	–	postherpetic neuralgia
PD	–	power density
POL	–	peroxide oxidation of lipids
RCT's	–	randomized controlled trials
RG	–	Remedial Gymnastics
AP	–	acupuncture point
TMV	–	tonic motor-vegetative system
TP	–	trigger point
UV	–	ultraviolet (range, spectrum)
UVBI	–	ultraviolet blood illumination
FM	–	fibromyalgia
PMV	–	phasic motor-vegetative system
CNS	–	central nervous system
ED	–	energy density

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S.V. Moskvina, S.B. Kisselev

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