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Chapter 2

BASIC TECHNIQUES OF LOW-LEVEL LASER THERAPY: MODERN TECHNOLOGIES FROM RUSSIA

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ABSTRACT

Currently, considerable experimental and clinical evidence has been accumulated enabling highly efficient laser therapy techniques to be proposed for hundreds of pathological conditions and diseases. Russian scholars, using systems analysis methods and understanding the mechanisms of the biomodulating action of low-intensity laser illumination, have studied the most optimal low-level laser therapy (LLLT) techniques and also confirmed their effectiveness in practice. This chapter presents some of these LLLT techniques, their rules, and the principles for their application.

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INTRODUCTION

Low-level laser therapy (LLLT) is one of the physiotherapy techniques that has been widely and actively used in Russia for over 50 years. Since 2000-2003, LLLT has begun to gain recognition in other countries, though its effectiveness had previously been considered unproven. This area of medicine developed quite strongly in the English-speaking scientific community (the number of publications is constantly and rapidly growing), but on the other hand, they are on the path of pure empiricism, blind trial, and error in trying to study questions which have long since been answered by Russian specialists [1]. And one fact must be recognized by everyone – only lasers can be used for laser therapy since the minimum width of the spectral line (monochromaticity) is the property of laser light that determines the unique therapeutic efficacy unattainable for lamps, light-emitting diodes, etc. [1].

There are many reasons for this, including, in particular, largely fundamental differences in the methodology of “Western” and “Eastern” medicine, a topic that we discussed in detail with Jan Tunér; the results of this correspondence were published [2]. The development of LLLT was significantly hampered by active criticism by powerful transnational corporations promoting alternative treatment methods (if LLLT is ineffective, why is it perceived as a dangerous competitor?). But the main reason LLLT is not widely accepted is the disregard of the unique scientific heritage and rich practical experience of Russian specialists, which is sometimes explained by the snobbery of some “colleagues”. For example, Wikipedia editors explicitly state that Russia does not have its own medical science or medicine at all, therefore they prohibit information about Russian research to be posted [3], and, as is known, they refer to LLLT as “alternative” medicine, i.e., shamans, voodoo, paranormalists and the like. However, the overwhelming majority of specialists understand that Russia has the best laser therapy techniques, scientifically based and proven by many years of experience in the large-scale application in thousands of medical centers throughout the country, but they cannot get this information because of the language barrier, as well as certain technical and organizational difficulties.

It should be understood that vast, significant experimental and clinical evidence has been accumulated, which has allowed highly effective laser therapy techniques to be developed for hundreds of pathological conditions and diseases. It is only necessary to generalize and systematize this knowledge using systems analysis, which we have successfully done to solve the problem of male infertility [4], [4], trophic ulcers and non-healing diabetic wounds [5] (we give only recent findings as an example).

In order to help foreign colleagues, we began implementing the program, "Laser Therapeutic Technologies from Russia", in 2016, which included translation of the best books and guidelines into foreign languages (first of all, they were translated into English), training specialists from different countries as well as publications in the leading English Language scientific journals. Moreover, all information is published exclusively with open access, is free and available to all interested persons.

While analyzing English Language publications concerning various aspects of biomedical low-intensity laser illumination (LILI) – whether experimental or clinical in nature – we noticed that in 99% of cases, completely incorrect parameters (techniques) of laser exposure were used. As a result, the authors of these studies got little or no effect and quite often had a negative and inverse result. It was quite obviously absurd and foolish to draw conclusions about the therapeutic method while incorrectly applying it. After all, no one would discuss the efficacy of the drug if, instead of ingestion in a strictly prescribed dosage, it was to be rubbed into the heel. So why was it done in research related to LLLT? When describing the materials and methods in terms of the LILI parameters, it was never explained from which considerations certain values were chosen. At best, it is reported that a laser device that was just available was chosen.

The correct and objective answer to the question about the optimal LILI parameters could be obtained only by understanding the mechanisms of the biomodulation action (BMA) of low-intensity laser light (LILL). In the introductory part of almost all relevant articles, the known effects of BMA LILL were only formally listed, and references were given to frequently cited publications without understanding the general meaning. However, most importantly, this was done without substantiating the optimal parameters of the technique.

Basic Rules for Setting the Parameters of Laser Therapy Technique

As a reminder, *all the parameters* of the technique must have *optimal* values:

- wavelength;
- mode (continuous, modulate or pulse);
- power (continuous or pulse);
- exposure (time of illumination);
- light spot area;
- area of illumination;
- number of procedures.

We repeat: All parameters should be optimal. Let us give clear examples of dos and don'ts.

1. If power is 1mW at an exposure of 1000s (or swapped: 1000mW and 1s), no result will be obtained. Optimal power is 10-20mW at an exposure of 100 or 300s.
2. The optimal power is determined by the laser therapy technique and quite often is set in a very limited range. For example, for laser acupuncture, power of no more than 2-3mW is used with a wavelength of 635nm and a continuous mode. The same power range for the same wavelength is most often used for the intravenous

laser blood illumination. The selection of the optimal power also directly depends on the wavelength, or rather, on the absorption coefficient associated with it. The stronger the laser light is absorbed by the cells or tissues, the lower the power should be.

3. There is even more confusion while determining the optimal power parameters for various laser therapy techniques in a pulsed illumination mode, when the pulsed power is set in watts and dozens of watts, and the average power, therefore, energy density, linearly depends on the pulse repetition rate. By the way, variation in frequency is the best way to optimize laser exposure.
4. The wavelength of the laser light is extremely important. If you choose 808nm and a power of 10mW, the result will not be obtained or will be completely minimal. If you choose the wavelength of 190nm (UVL), there may be problems. There will certainly be no chance of stimulating the proliferation of the cells *in vitro* with such UV light.
5. Very often the laser beam is focused almost to a point with an absolutely incomprehensible goal (in my personal experience). What does this lead to? For example, if a light spot has a diameter of 1mm, its area will be ~0.01cm^2. In this case, in order to obtain the 'optimal' energy density, it is necessary to reduce the power to 0.1mW, and in the end, no results will be obtained. The topic of optimizing the illumination area is not simple; it requires a separate, more detailed publication (justification). However, it is more than safe to say that the minimum area should be ≥1cm^2, and the maximum area is determined by the size of the illumination object. Everything is explained quite simply – the number of cells that fall into the illumination area is important, and it is not changed when the size of the light spot decreases below the specified limit. Therefore, it is pointless to engage in the division by this microscopic area.
6. Exposure is a parameter determined by biological (physiological) rhythms and is almost not subject to variation. This topic also requires a more detailed analysis. I hope the journal management

will allow this to be done in the near future. Meanwhile, it can only be assumed that the optimal time for local illumination is 100 and 300s, and it is strongly prohibited to illuminate one zone for more than 5min (300s). This requirement, like all other conclusions, is a direct consequence of our proposed thermodynamic model of the LILI biomodulating action, according to which low-power, low-energy laser light causes waves of increased calcium ion concentration in cells, which then spread throughout the cell, initiating Ca^{2+}-dependent processes. In all cell types, waves of increased Ca^{2+} concentration have constant periods of propagation (maxima) amounting to 100s and 300s. Accordingly, during illumination of some tissue or organ, these waves simultaneously appear and synchronously propagate in all cells. It has been unambiguously proven that with an increased exposure time of 7-10min, the effect disappears first, and then transforms into an inverse form – instead of the expected stimulation, inhibition occurs.

7. The total time of the procedure (illumination of all laser-exposed zones) should not exceed 20min. This limitation is associated with the response time of the central nervous system, which responds to laser illumination with some delay. But as soon as the central regulatory mechanisms are activated in the process, illumination must be stopped.
8. For some techniques, the exposure time is strictly defined and not subject to variation. For example, laser acupuncture takes 20-40s per a corporal point.

Thus, all the parameters of laser illumination are important (and they must be set separately, with optimal values selected for each of them).

Our confidence that the above mentioned general recommendations and the parameters of particular laser therapy techniques are most optimal is based on understanding the BMA LILL mechanisms (described below) and confirmed by more than 50 years of practical experience in the application of laser therapy by many thousands of Russian doctors. The theory (model) of the BMA LILL mechanisms, as proposed by us, perfectly explains the available facts and regularities, and also makes it possible to predict the result with very high probability by modifying the parameters of the laser illumination technique. Of all existing theories, only ours is able to do this. The practice is the criterion of truth.

MECHANISMS OF THE THERAPEUTIC EFFECT OF LOW-LEVEL LASER THERAPY

The process of therapeutic effects of low-level laser illumination (coherent, monochromatic and polarized light) can be conventionally divided into three main stages:

1. primary effects (change of state of the electronic levels of the living matter of molecules, the stereo-chemical rearrangement of molecules, the local thermodynamic shifts and the emergence of an increased concentration of calcium ions in the cytosol);
2. secondary effects (propagation of waves of increased Ca^{2+} concentration in the cell, between cells, stimulation or inhibition of biological processes at a cellular level and changes in the functional state of individual biological cell systems and the body as a whole);
3. residual after-effects (formation of tissue metabolism products, the response of the immune, endocrine, and neurohumoral regulation systems, etc.).

All this variety of developing processes determines the widest range of the body’s responses to laser illumination. Figure 1 shows virtually the entire sequence of events starting from the initial act of photon absorption and finishing with effects at the ‘whole body’ level. This explains numerous if not all known phenomena in this field of biology and medicine.

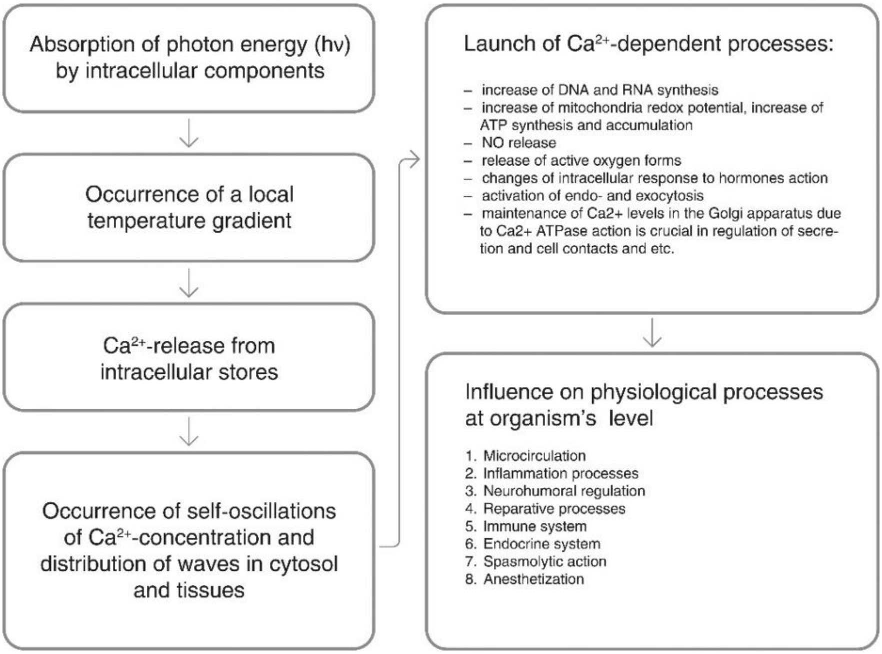

Figure 1. The sequence of the developing biological effects of laser exposure.

It was previously shown that the initial starting moment of the biological effects of LILI is a local violation of the thermodynamic equilibrium, causing the release of calcium ions from the intracellular store and the propagation of waves with an increased concentration of Ca^{2+} in the cytosol of the cell, triggering Ca^{2+}-dependent processes [3], [7], [7], [8], [9]. Then secondary effects develop, which are a complex of the non-specific adaptive and compensatory reactions that occur in the tissues, organs, and entire living body, among which the following: effects are distinguished most often:

- activation of the cell metabolism and increase in its functional activity,
- stimulation of reparative processes,
- anti-inflammatory effect,
- activation of blood microcirculation and central hemodynamics,
- increase in tissue trophic support,

- analgesic and immunomodulatory effect,
- reflexogenic impact on the functional activity of various organs and systems.

Numerous studies have shown that LILI acts as an activator of cellular responses aimed at restoring and normalizing the bioenergetic status of the body's tissues and immune system. LILI increases enzymatic and catalase activity, the permeability of the cytoplasmic membranes, contributing to the acceleration of metabolic and transport processes in tissues. Accelerated oxygen exchange reduces hypoxia accompanying inflammatory processes.

LILI activates the regenerative processes in pathological conditions (trauma, surgical procedures, transplantation) due to changes in the cellular composition in the area of the wound or ulcer by increasing the number of neutrophils, as well as by accelerating the growth of capillaries and accumulating collagen produced by them, which determines the speed and quality of wound or ulcer surface epithelialization. In addition, hormonal and neurotransmitter components of the adaptive mechanism are activated. An increase in non-specific immunity of the body after LILI exposure is confirmed by the rising titer of hemagglutinin, hemolysins, lysozyme, activation of neutrophils and interferons, increased the synthesis of immunoglobulins and changed function and structure of plasma membranes and increase in the number of lymphocyte blast forms.

Laser illumination reduces the concentration of lipid peroxidation products in the blood, enhancing the antioxidant system, increases the level of catalase, activates the cellular elements of mononuclear phagocytes (macrophages) that stimulate cell proliferation and accelerates restoration of the morpho-functional state of the cell membranes.

In development of the body response, an important role is played by the impact of LILI on the blood, exerting a beneficial complex (systematic) influence caused by common hemocirculation. Studies using vital microscopy, computer capillaroscopy, and photographic recording showed an increase in the number of functioning capillaries, acceleration of blood flow and normalization of microcirculation in general. Central hemodynamics is changing as well; it is proved that LILI has venomotor and artery dilation effects in case of initially decreased indicators.

Low-level laser therapy, conducted before the start of any surgical intervention in order to prevent infiltration and suppuration, improves local blood circulation, metabolism, oxygenation, and maintenance of the trophic support of tissues, which stabilizes the postoperative course, reducing the probability of developing complications by several times.

LILI's ability to increase the content of neurohormones in tissues, to involve various specific proteins of cell membranes in the process which activate enzymes such as adenocyclase, adenylate cyclase, adenyl cyclase, phosphodiesterase and calcium ions, altering the intra- and extracellular metabolism, to affect sensitive components of intercellular spaces leads to the normalization of the local and general physiological response, contributes to the preservation or restoration of homeostasis and body adaptation to stress conditions.

LOW-LEVEL LASER THERAPY PROTOCOLS

Fulfilling all the requirements for the implementation of the low-level laser therapy protocols is mandatory since the need to set all the parameters of methods listed below is clearly proved. Even one wrong value will not allow getting a predictable and adequate response to laser light action and the desired therapeutic effect, respectively.

Setting energy parameters substantially depends on the laser operating mode and technique. A majority of Russian devices have a laser hazard Class 1M or 2M according to IEC 60825-1:2007, while foreign lasers mainly have the laser hazard Class 3R, which greatly complicates their application. Moreover, most cases require minimal energy of LILI to successfully implement low-level laser therapy techniques and increased power and exposure (energy) can result in an inhibitory effect, i.e., complications.

All techniques of low-level laser therapy must contain the following information [11].

1. Laser light wavelength as measured in nanometers [nm] [11]. The most wide-spread LT spectral ranges are:
   - 365–405nm – ultraviolet (UV) spectrum,
   - 440–445nm – blue spectrum,
   - 520–525nm – green spectrum,
   - 635nm – red spectrum,
   - 780–785nm – infrared (IR) spectrum,
   - 890–904nm – infrared (IR) spectrum.

   It is inadmissible to illuminate one and the same area simultaneously with lasers having different wavelengths or incoherent light sources due to inhibiting interference.
2. Laser operational mode: continuous, modulated, pulsed.
3. Beam output power.

   The average power of continuous lasers operating in continuous and modulated modes is measured in *milliwatts* [mW], the pulse (peak) power of pulsed lasers is measured in *watts* [W].
4. The modulation frequency or pulse repetition frequency for pulse mode is the number of vibrations (pulses) per unit time (second). It is measured in hertz [Hz, 1/s].
5. The most important parameter of pulsed lasers is the duration of the light pulse, it is a constant (most commonly 100–150ns). The average power of pulsed lasers ($P_{av.}$) is directly proportional to the pulsed power (P_p), pulse duration (τ_p) and frequency (F_p): $P_{av.} = P_p \times \tau_p \times F_p$.
6. Illumination area is measured in square centimeters [cm^2].

   The required area is almost always provided by the procedure without carrying out unnecessary measurements, for example, in the contact-mirror method the area is assumed to be $1cm^2$. In matrix emitters, laser diodes must be positioned so that the area of their impact would provide the multiplicity in power density. For example, 8 (most often) pulsed laser diodes having a power of 10W shall be disposed on the surface of $8cm^2$, and in contact with the skin through a transparent tip power density (PD) will be $10W/cm^2$, respectively. During laser acupuncture or intravenous laser blood illumination (ILBI) the area is not specified, as the exposed zone is too small, and the leading role is played by scattering and absorption of the laser light energy in the volume of biological tissues.

7. Power density is measured in watts (for pulsed lasers) or milliwatts per square centimeter [W/cm^2 or mW/cm^2].
8. The exposure (the exposure time) per one zone and total time for the procedure are measured in seconds [s] or minutes [min].
9. Localization of action (technique), the exposed zones should be specified.
10. The number of procedures per course and their frequency.

Calculations of energy, which is measured in Joules [J or W·s] or energy density [J/cm^2 or W·s/cm^2] *shall not be carried out*, because this information is not necessary to provide effective low-level laser therapy.

It is recommended to include one of the methods of overall impact into the protocol (laser acupuncture or ILBI), and the methods for directly illuminating the affected area by zones (local, transcutaneous or abdominal procedures, as well as the combined method – laser phoresis) [13], [13], [15].

Local LILI is administered directly on the affected area, located close to the surface of the body, either through direct contact through the mirror nozzle or by distance, in a stable manner, at a short distance from the surface (1–2cm), if it is impossible to provide direct contact. Sometimes a combined physiotherapy method – magnetic low-level laser therapy – is used with a laser beam acting through the opening of a permanent magnet, with an induction of 35–50mT [3].

The following procedures are used most often for local laser exposure (Tables 1–3):

- continuous LILI of the red spectrum (635nm), PD – 10–15mW/cm^2,
- pulsed LILI of the red spectrum (635nm), PD – 4–5W/cm^2, pulse duration of 100–150ns, frequency of 80–10,000Hz,
- pulsed IR LILI (890–904nm), PD – 8–10W/cm^2, pulse duration of 100–150ns, frequency of 80–10,000Hz.

Table 1. Parameters of contact-mirror and distant low-level laser therapy techniques

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	445 (blue), 525 (green), 635 (red), 780, 808, 904 (IR)	Emitting head with one laser
Laser operational mode	Continuous	445, 525, 635, 780, 808nm
	Pulsed	635 and 904nm
Duration of the light pulse, ns	100–150	For pulsed mode
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 pulsed mode
Exposure per one zone, minutes	2 or 5	–
Number of the exposed zones	1–4	–
Localization	On affected area	–
Technique	Contact-mirror	With the use of a mirror or magnetic nozzle attachments
Number of procedures per course	5–12	Daily or on alternate days

The frequency for pulsed lasers varies depending on the desired effect: regeneration and antiinflamation – 80-150Hz, anesthesia – 3,000-10,000Hz [15]; [17]. One area includes up to 2–3 local zones, the exposure for each zone being 2–5 minutes. It is strictly forbidden to illuminate one area (local zone) for more than 5 minutes!

Attention should be paid to the peculiarities of pain management. There are five standard schemes of laser therapy to choose from depending on the situation (the pathogenesis of a disease). This issue requires detailed consideration in a separate chapter, it must be understood that pain management should not be a goal in itself, it is necessary to eliminate the cause of the pain [15], [17]. Most often, but not always, the frequency of 10,000 Hz is used for anesthesia; however, pulsed lasers are indispensable [18].

Table 2. Parameters of contact technique for matrix laser emitting heads

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	635 (red)	–
	904 (IR)	
Laser operational mode	Pulsed	Matrix emitter consisting of 8 laser diodes of the total surface area of 10cm^2
Duration of the light pulse, ns	100–150	For pulsed mode
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 intended exposure and wavelength
Exposure per one zone, minutes	1.5–2 or 5	–
Number of the exposed zones	1–4	–
Localization	On the affected area and the projection of the internal organs	–
Technique	Contact	Through a transparent nozzle PMN
Number of procedures per course	5–12	Daily or on alternate days

Table 3. Parameters of contact low-level laser therapy technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	780, 808, 904 (IR)	Emitting head with one laser
Laser operational mode	Continuous	780nm and 808nm
	Pulsed	904nm
Duration of the light pulse, ns	100–150	For pulsed mode
Power	100–200mW	780 and 808nm
	80–100W	904nm
Power density	–	The maximum possible
Frequency, Hz	3000–10,000	For pulsed mode
Exposure per one zone, minutes	5	In some techniques exposure is allowed to be up to 30 minutes
Number of the exposed zones	1–4	Most often symmetrically
Localization	On affected area	–
Technique	Contact	Directly touching the surface with the laser diode
Number of procedures per course	15–20	Generally, this is done daily. The course is repeated in a month

Local action of LILI on the projection of the affected organ differs from surface illumination, as only pulsed infrared lasers are used, and matrix lasers are desirable to ensure a therapeutic effect at a depth of 15cm: wavelength 890-904nm, PD – 8-10W/cm^2, pulse duration of 100–150ns, frequency of 80–10,000Hz (Table 2). By increasing the frequency in pulsed lasers, the average illumination power increases proportionally as well, which allows the influencing of deeper areas. It is strictly forbidden to illuminate one area for more than 5 minutes.

Table 4. Parameters of laser acupuncture technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	525 (green)	On auricular AP
	635 (red)	On corporal AP
Laser operational mode	Continuous or modulated	–
Frequency, Hz	In a recipe	Only for modulated mode
Power*, mW	0.5–1	525nm
	2–3	635nm
Exposure per 1 AP, s	5–10	On auricular AP
	20–40	On corporal AP
Number of the exposed zones	Up to 15	–
Localization	In a recipe	On auricular AP
	In a recipe	On corporal AP
Technique	Contact	Through an acupuncture nozzle
Number of procedures per course	10–12	Daily

* – at the output of an acupuncture nozzle.

Laser acupuncture is carried out by means of a special acupuncture nozzle designed for concentrating the laser light energy into a zone of 1-2 mm in diameter. The wavelength is 635nm (red spectrum), continuous or modulated modes are used, the nozzle output power is 2-3mW, exposure per one corporal acupuncture point ranges from 20 to 40s, making it 5-10s per auricular point. It is unacceptable to exceed the specified exposure time (Table 4).

Laser blood illumination provides for two options for a procedure: via intravenous or non-invasive (extravenous, external, percutaneous, transcutaneous) access. Accordingly, these are called intravenous laser blood illumination (ILBI) and non-invasive (extravenous, transcutaneous, percutaneous) laser blood illumination (NLBI).

Figure 2. Laser therapeutic device.

The devices for LLLT (Figure 2) allow carrying out both intravenous and non-invasive laser blood illumination, as well as other methods of laser exposure. The maximum effectiveness of treatment is also based on the optimized design of the laser heads, e.g., a special system of fixing disposable light guides and the heads on the arm is used for ILBI (Figure 2, bottom left), matrix emitting heads are used for NLBI (Figure 2, bottom right, and Figure 3).

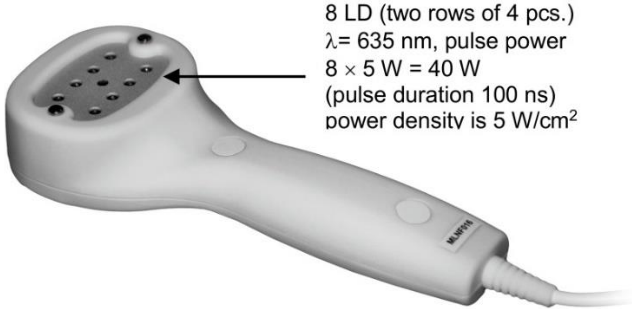

Figure 3. The Matrix laser emitting head for NLBI, contact and distant techniques, as well as for the projection of the internal organs.

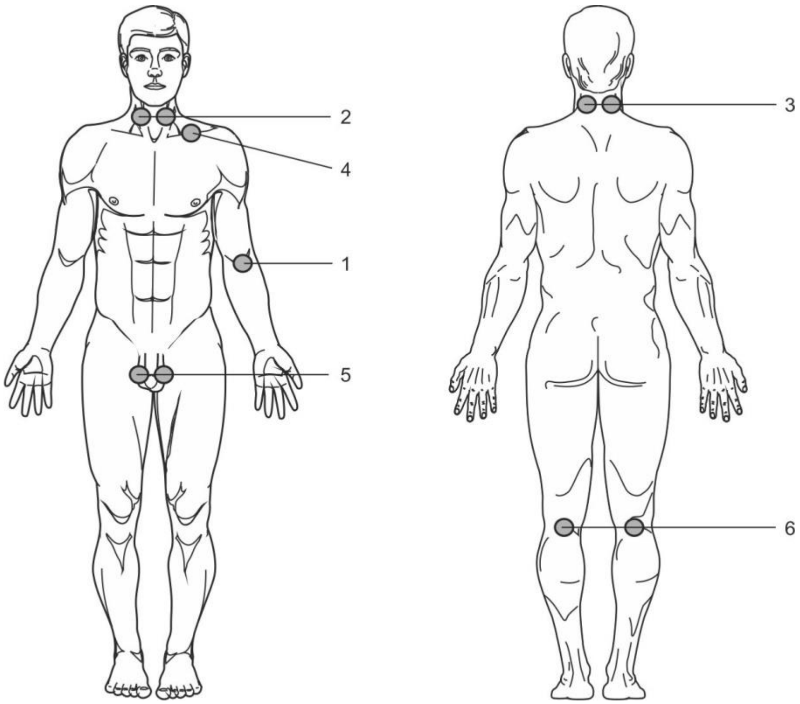

Figure 4. The basic exposed zones for laser blood illumination.

For ILBI, LILI is always used in continuous mode, laser action is carried out intravenously through a special disposable sterile light guide with a puncture needle most often in the cubital vein (Figure 4, zone 1) [13], [19], [20].

To implement ILBI, different techniques are currently applied using laser light of different spectra (Tables 5 and 6):

- *ILBI-635* (wavelength 635nm, red spectrum, power 1.5–2mW, exposure for 10–20 minutes) has a universal effect, making a positive impact both on the immune system, and provides the trophic support of tissues.
- *ILBI-525* (wavelength 525nm, green spectrum, power 1.5–2mW, exposure of 7–8 minutes) is recommended to ensure maximum gain of trophic support of tissues.

- *ILBI-405* (wavelength 365–405nm, power 1.5–2mW, exposure of 3–5 minutes) or laser ultraviolet blood illumination (LUVBI®) should be preferably used for the correction of immune disorders of various etiologies. It is most efficient to alternate the exposure to different wavelengths every other day [19], [21], [22], [23].

Table 5. ILBI-525 + LUVBI® technique (basic)

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	365–405 (UV)	LUVBI®
	520–525 (green)	ILBI-525
Laser operational mode	Continuous	–
Power*, mW	1.5–2	At the output of a disposable light guide
Exposure, minutes	3–5	LUVBI®
	7–8	ILBI-525
Localization	Median cubital vein (*v. mediana cubiti*)	–
Technique	Intravenously	Through a disposable sterile light guide
Number of procedures per course	10–12	Daily, alternating ILBI-525 and LUVBI® every other day

Non-invasive laser blood illumination (NLBI) is carried out on large blood vessels, adjacent to the center of the lesion focus. Pulsed lasers, preferably of the red (635nm) and infrared (890–904nm) spectra and matrix emitters (8 laser diodes) or, as an option, a single laser with a mirror nozzle are used mainly for NLBI (Table 7) [13], [19]:

- pulsed LILI of red spectrum (635nm), PD – 4–5W/cm^2, pulse duration of 100–150ns, frequency of 80Hz,

- pulsed infrared LILI (890–904nm), PD – 8–10W/cm^2, pulse duration of 100–150ns, frequency of 80Hz.

Table 6. ILBI-635 + LUVBI® technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	365–405 (UV)	LUVBI®
	635 (red)	ILBI-635
Laser operational mode	Continuous	–
Power*, mW	1.5–2	At the output of a disposable light guide
Exposure, minutes	3–5	LUVBI®
	10–20	ILBI-635
Localization	Median cubital vein (v. mediana cubiti)	–
Technique	Intravenously	Through a disposable sterile light guide
Number of procedures per course	10–12	Daily, alternating ILBI-635 and LUVBI® every other day

The following exposure localizations are used for NLBI (Figure 4):

- projection of the common carotid artery (sinocarotid zone) symmetrically (zone 2),
- projection of the vertebral artery symmetrically (zone 3),
- left supraclavicular area (zone 4),
- vascular bundles in the groin symmetrically (zone 5);
- popliteal fossa symmetrically (zone 6).

Pulse repetition frequency is fixed (80–150Hz), the question of possibility and admissibility of increasing the frequency (i.e., the average power for pulsed lasers) has not been studied at present. It is recommended to illuminate symmetrical zones, the exposure for each zone needs to be 2–

5 minutes. It is strictly forbidden to illuminate one area for more than 5 minutes!

Table 7. NLBI technique

Parameter	Value	Notes
Laser light wavelength, nm (spectrum)	635 (red)	NLBI-635
	904 (IR)	NLBI-904
Laser operational mode	Pulsed	–
Duration of the light pulse, ns	100–150	–
Power, W	30–40	Matrix emitting head, NLBI-635
	60–80	Matrix emitting head, NLBI-904
Power density, W/cm^2 (surface area 10cm^2)	3–4	NLBI-635
	6–8	NLBI-904
Frequency, Hz	80–150	–
Exposure per one zone, minutes	2–5	–
Number of the exposed zones	2–4	Symmetrically
Localization	On the projection of large blood vessels close to the lesions	Refer to the text
Technique	Contact	Through a transparent nozzle
Number of procedures per course	10–12	Daily

We draw your attention to the fact that the *endonasal technique* of laser blood illumination does not exist; this term is often used by fraudsters whose recommendations can harm women’s health [24].

The Intracavitary procedure is intended to deliver laser light energy to the affected area, located in a natural cavity (endonasal, endoauricular, etc.), via a special light guide instrument (optical fiber). A feature of this procedure is the need to introduce most of the energy in the fiber, followed by its distribution inside along the given indicatrix, however, since PD is not always determined in this case, the illumination power is set at the nozzle inlet, i.e., is measured without the nozzle. The following procedures are used most often for laser exposure:

- continuous LILI of the red spectrum (635nm), power – 10–15mW,
- pulsed LILI of the red spectrum (635nm), power – 4–5W, pulse duration 100–150ns, frequency of 80–150Hz,
- pulsed infrared LILI (890–904nm), power – 15–20W, pulse duration 100–150ns, frequency of 80–10,000Hz.

To deliver pulsed IR LILI (890–904nm), it is required to use only the quartz-polymer fiber, as the polymer (PMMA) absorbs nearly all the illumination with wavelengths longer than 830nm. It is strictly forbidden to illuminate one area for more than 5 minutes.

Laser phoresis is one of the more modern practices of physical and pharmacological methods of the combined percutaneous application of LILI and medicinal preparations. As a result of LILI on the area which is previously applied with the biologically active substance in the form of gel or an aqueous solution, its penetration through skin (pores, hair follicles) is activated. Such percutaneous injection-free method of substance administration is possible only with low molecular weight (no more than 500 kDa) and hydrophilic compounds [15].

The technique parameters:

- continuous LILI of the red spectrum (635nm), PD – 10–15mW/cm^2,
- continuous infrared LILI (780–790nm), PD – 40–50mW/cm^2,
- pulsed infrared LILI (890–904nm), PD – 8–10W/cm^2, pulse duration of 100–150ns, frequency of 80Hz.

For pulsed lasers, frequency is not changed. One area may have up to 15–20 local areas, with an exposure time of 1–1.5 minutes for each zone, but no more than 20 minutes in total.

The presented principles of the low-level laser therapy procedures formation may be adjusted in some cases, except for the exposure. Varying the exposure time is not allowed, because it is determined by physiological rhythms, synchronization with which necessarily underlies any laser treatment techniques. In some cases, it is possible to adjust LILI energy parameters, for example, for pain relief or suppression of excessive proliferation it is required to set up extremely high frequencies – up to 10,000Hz (recommendation refers exclusively to the pulsed lasers with a pulse duration of 100–200ns and pulsed (peak) output power up to 300W).

Combining laser therapy techniques with plasmapheresis [25] and EHF-therapy is effective [26]. In many respects, it is obligatory to know fundamentally different approaches to laser therapy methodology in pediatrics, as well as the relevant rules and restrictions [27], [27].

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