Blood Irradiation

Laser Irradiation of the Blood

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Abstract

Evaluation of the methods of intravenous a transcutaneous irradiation of blood, known especially from scientific papers of Russian and Soviet authors. The article points out positive effects of laser irradiation on strengthening of the entire immune system.

Intravenous Laser Blood Irradiation Therapy

Currently the methods of laser and non-laser (incoherent monochromic, narrow-band or broadband) light blood irradiation therapy - the methods of photo-hemotherapy - are widely applied in the treatment of different pathologies. Direct intravenous and extracorporeal (with red, UV and blue light) as well as transcutaneous (with red and infrared light) irradiation of blood are used. Unlike the treatment mechanisms of local laser therapy, the medical effects of photo-hemotherapy methods are determined by predominance of systemic healing mechanisms above the local ones, increasing the functioning efficacy of vascular, respiratory, immune, other systems and organism as a whole.

The method of HeNe intravenous laser blood irradiation (LBI) was developed in experiment and introduced in clinic in 1981 by Soviet scientists E.N. Meshalkin and V.S. Sergievskiy. Originally the method was applied in the treatment of cardiovascular pathologies. Some authors reported that the treatment possibilities of the method are very large and include the improvement of rheological characteristics of the blood and microcirculation, normalisation of parameters of hormonal, immune, reproductive and many other systems.

HeNe laser (632.8 nm) is generally used for carrying out the intravenous laser blood irradiation (IV LBI). Usual parameters of blood irradiation procedure are: output power at the end of the light-guide inserted into a vein from 1 up to 3mW, exposition 20 - 60 minutes. Procedures are conducted on a daily base, from 3 up to 10 sessions on a course of therapy.

It was shown, that IV HeNe LBI stimulates the immune response of the organism, activates erythrogenesis and improves deformability of erythrocyte membranes, has anti-

hypoxic activity on tissues and general antitoxic influence on the organism at different pathological processes. IV LBI is used for its biostimulative, analgetic, antiallergic, immunocorrective, antitoxic, vasodilative, antiarrhythmic, antibacterial, antihypoxic, spasmolytic, anti-inflammatory and some other properties.

IV LBI activates nonspecific mechanisms of anti-infectious immunity. Intensifying of bactericidal activity of serum of the blood and system of the complement, reduction of the degree of C - reactive protein, level of average molecules and toxicity of plasma, increasing the content of IgA, IgM and IgG in the serum of the blood, as well as decreasing of the level of circulating immune complexes are proved. There are studies on boosting effect of IV LBI on the cellular part of immunity (N. F. Gamaleya et al., 1991). Under influence of IV LBI the phagocytic activity of macrophages markedly increases, concentration of microbes in exudate in the abdominal cavity of patients with peritonitis decreases, reduction of inflammatory exhibiting of disease, activation of microcirculation are detected.

The medical effect of IV LBI is stipulated by its immuno-corrective activity by normalisation of intercellular relationships within the subpopulation of T-lymphocytes and increasing the amount of immune cells in a blood. It elevates the function activity of B-lymphocytes, strengthens the immune response, reduces the degree of intoxication and as a result improves the general condition of patients (V. S. Sergievskiy et al., 1991).

IV LBI promotes improving the rheological properties of blood, rising fluidity and activating transport functions. That is accompanied by increasing the oxygen level, as well as decreasing the carbon dioxide partial pressure. The arterio-venous difference by oxygen is enlarged, that testifies the liquidation of a tissue hypoxia and enrichment the oxygenation. It is a sign of normalisation of tissue metabolism. Probably, the basis of activation of oxygen transport function of IV LBI is the influence on hemoglobin with transforming it in more favorable conformation state. The augmentation of oxygen level improves metabolism of the organism tissues. In addition, the laser irradiation activates the ATP synthesis and energy formation in cells (A. S. Krjuk et al., 1986). Application of IV LBI in cardiology has shown that procedures have analgetic effect, show reliable rising tolerance of patients towards physical tolerance test, elongation of the period of remission.

It was proved that IV LBI reduces aggregation ability of thrombocytes, activates fibrinolysis, which results in peripheral blood flow velocity increasing and tissues oxygenation enriching. The improvement of microcirculation and utilisation of oxygen in tissues as a result of IV LBI is intimately linked with positive influence on metabolism: higher level of oxidation of energy-carrying molecules of glucose, pyruvate, and other substances.

The improvement in microcirculation system is also stipulated by vasodilation and change in rheological properties of blood as a result of drop of its viscosity, decrease of aggregation activity of erythrocytes due to changes of their physicochemical properties, in particular rising of negative electric charge. Finally the activation of microcirculation,

unblocking of capillaries and collaterals, improvement of tissue trophical activity, normalisation of a nervous excitability take place (N. N. Kapshidze et al., 1993).

IV LBI is recommended to apply before surgical operations as preparation for intervention, as well as in the postoperative stage, because the laser irradiation of blood has not only analgetic effect, but also spasmolytic and sedative activity.
IV LBI procedures on patients with chronic glomerulonephritis allow overcoming resistance towards medicament therapy (glucocorticoid, cytostatic, hypotensive and diuretic drugs).

IV LBI promotes rising of concentration of antibiotics in the focus of inflammation as a result of improvement the microcirculation in the focus of inflammation, as well as normalisation the morphology and functional activity of the affected organ as a whole.

IV LBI procedures have found broad application in obstetrics and gynecology for activation the blood flow in utero-placental and feto-placental basins, for prophylaxis of the pathologies at delivery, for influence on inflammatory processes of inner genital organs. IV LBI normalises production of gonadotropins, improves microcirculation, elevates oxygen pressure in blood and in tissues, and so accelerates the process of regeneration and reparation.

In order to explain the generalised and multifactor effects of IV LBI, its positive influence practically on all tissues and functional systems of the body, clinical effectiveness for the treatment of different diseases, some authors mentioned that the improvement of microcirculation after IV LBI is detected in all structures of central nervous system, but this improvement is most active in the hypothalamus, which has highly developed vascular system. The capillaries of a hypothalamus are remarkable for high permeability for macro-molecular proteins, which should even more amplify influence of the irradiated blood to subthalamic nuclei. So it is supposed, that IV LBI increases the functional activity of hypothalamus and all limbic system, and as a result the activation of energetic, metabolism, immune and vegetative responses, mobilization of adaptive reserves of an organism is reached.

Transcutaneous Laser Blood Irradiation Therapy

The application in clinics of the non-invasive and relatively simple method of infrared (IR) transcutaneous laser irradiation of blood becomes possible after development of suitable IR semiconductor laser diodes. For transcutaneous LBI lasers with red (630-670 nm) or near IR (800-1300 nm) irradiation band are applied. Laser light is delivered to the skin on a projection of large veins or arteries via special nozzles.

Some recent studies suggested that it is possible to achieve the medical effect similar to effect of IV HeNe LBI, without intravenous manipulations - by transcutaneous laser blood irradiation (TLBI).The procedure of TLBI has the greatest application in children's practice. The method is founded on a relatively high permeability of the skin and hypodermic tissues for radiation of red and especially of IR spectrum. It is supposed, that the efficacy of 20 mW HeNe laser transcutaneous blood irradiation is equal to 1 mW HeNe laser intravenous blood irradiation. In the same time TLBI procedures are non-

invasive and painless. Recently non-laser light sources are also applied for transcutaneous blood irradiation.

Unfortunately, there are not enough qualified works on comparing medical and biological effects of IV and transcutaneous LBI to make the final suggestions about clinical equality of these methods. Brill (1994) suggested that the effects of the laser therapy depend on the method of irradiation. He considered, that the term "transcutaneous laser blood irradiation" is disorientating, as it skips the significance in definition of bioeffect of irritation of receptors of the skin and acupuncture points, dermal cells (including mast cells), aditional elements of the vascular wall and other formations, which are subject to the irradiation. Today there are no ground to consider, that the positive therapeutic effect of laser irradiation of skin is a result of influence only of that part of energy, which penetrates the skin and is absorbed by blood and its components. With good reasons it is possible to speak about transcutaneous laser irradiation, with indication of the place of delivery of laser light.

Blue Light Blood Irradiation Therapy

Currently the methods of laser and non-laser (incoherent monochromic, narrow-band or broadband) light blood irradiation therapy - the methods of photohemotherapy - are widely applied in the treatment of different pathologies.

H. Kost et al. (1986) offered blood irradiation with incoherent narrow-band blue light for the treatment of patients with ischemic heart disease and hypertensive disease. The drop in low-density lipoproteins and cholesterol content of the blood serum was determined. Further studies proved the broad therapeutic activity of the blue light blood irradiation procedures.

In studies of medico-biological effects of extracorporeal blue light irradiation of blood V. I. Karandashov et al. (1996, 2000) detected dropping of viscosity of blood immediately after the reinfusion. The viscosity of the blood plasma also was reduced, but to less degree than viscosity of blood, and had correlation with concentration of blood proteins. All these have results in augmentation of flowability of blood and improvement of microcirculation.

The changes of viscosity of blood and hematocrit are determined by intravascular dilution of extravascular fluid with lower concentration of high molecular weight proteins. After the completing the course of irradiation the viscosity of blood was always lower than it was before the treatment. The decrease of concentration of cholesterol, triglycerides, lipoproteins and glucose was also marked. Thus, the phototherapy by blue light did not damage the blood cells, but stipulated dropping of concentration of atherogenous lipids, glucose and bilirubin. The obtained alterations had tendency to increase and stabilisation at carrying out of a course of phototherapy. At the same time studies showed that blue light does not affect the rheological properties of the blood in vitro.

The infusion of the blood irradiated with blue light had immunostimulative activity for patients with chronic asthmatic bronchitis. It was also shown that immediately after the

infusion of irradiated blood all main parameters of respiratory function were improved, and the increasing of effect was detected during and after the course of treatment.

Blue light blood irradiation therapy presents very good results in the treatment of different pathologies. It looks like it combines the best properties of both UBI and LBI procedures. Probably in the near future the blue light blood irradiation therapy will be used much more actively, than today.

ROLE OF THE CIRCULATING BLOOD IN INITIATION OF THERAPEUTIC EFFECTS OF VISIBLE LIGHT

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The successful use in Russia of the extracorporeal and intravascular irradiation of the patient`s blood with the laser and non-laser light for the wound healing promotion, immunomodulation, pain relief, etc. suggests that development of these effect in the case of the percutaneous light application also is due to its effect on blood. Such mechanism seems quite possible, as the visible and IR light penetrating the skin at the depth of 2-4 mm reaches a network of small vessels and can affect the blood that circulates here at a low rate. Since during the laser treatment it is possible to irradiate only a small area of the surface body or wound and, correspondingly, of a very small volume of the circulating blood, it is necessary to explain how its photomodification can lead to a wide spectrum of therapeutic effects. For this purpose, we refer to the data obtained at our Laboratory in studying mechanisms of the rapidly developing functional changes induced by retransfusions of a small blood volume (1.5-2.5% of its circulating pool) irradiated extracorporally with the UV or He-Ne laser light. It has been found out that the optical radiation induces structural-functional changes and activation of blood cells, which results in that a small volume of blood acquires properties of an active preparation able to modulate the state of cells of the autologous blood and other tissues. Indeed, when the photomodified blood is added in vitro to the 10-80-fold volume of the intact autologous blood, it "translates" to it the light-induced changes that, in spite of such a pronounced dilution of blood, not only are not reduced but even are enhanced. As a result, the entire volume of the circulating blood acquires properties of an active preparation. The chief "translators" of the light effects are the irradiated mononuclear leukocytes and platelets, and whereas development of some effects (improvement of hemorheology, activation of all types of leucocytes, etc), is necessarily associated with the presence of irradiated cells, the development of other effects (first of all an enhancement of the growth promoting activity of blood) is initiated by soluble factors secreted by these cells. By now we have accumulated an evidence for that after exposure of a small area of the body to visible incoherent polarized light, immediate changes occur of the rheological, transport, gas transport, growth stimulating, immunomodulating properties of the circulating blood and that these changes develop mainly as a consequence of the effect of the transcutaneously photomodified blood.

Experimental study of low level laser radiation effects on human blood cells.

Siposan D, Adalbert L (Bucharest, Roumania).

Fresh blood from 40 apparently healthy individuals has been irradiated with a low level HeNe laser, using EDTA anticoagulant. Doses ranged between 0-54 J/cm2. The authors watched the relative variation to the received doses of hemoreological constants - erythrocytary and leukocytary indices, as well as the variation of some erythrocytary aggreagability indices-viscocity, BSR. Following irradiation a lowering of the erythrocytary aggreagability (viscosity), BSR, and changes of some erythrocytary and leukocytary indices have been observed. The effect of low-level laser radiation on the red cell confirms the non-resonant mechanism of this bio-stimulating radiation effect by the changes in the cell membrane, in our case the blood cells, by revitalizing the red blood cell functional capacities and by several biochemical effects on the membrane level, that are to be studied thoroughly in future studies. It is concluded that the physical-biochemical and biological effects on blood can influence the physical-chemical parameters needed for long storage of blood products as well as the quick revitalization of the erythrocytary membrane aggressed physically and biochemically, in order to perform its oxophoric function in transfusion procedures.

Dynamics of lipid metabolism and peripheral blood flow rates in patients with atherosclerosis in conjunction with renal dysfunction after the course of combined laser therapy.

Kovalyova T V et al.

During an 8 year period patients with atherosclerosis and renal dysfunction have been treated with intravenous laser blood irradiation (ILBI). The study has demonstrated a decreased level of total cholesterol, LDL cholesterol and triglycerides with an simultaneous increase of HDL cholesterol levels. No pharmaceuticals were given during the treatment period. The authors state that ILBI results in a stable hypolipidemic situation which prevents atherogenesis in patients with metabolic disorders, particularly in patients with renal pathologies.

Cytological parameters of bronchoalveolar lavage in patients with chronic obstructive bronchitis exposed to laser radiation of blood].

Terapevticheskii arkhiv. 1999; 71(11): 65-67.
Ananchenko V G, Khanin A G, Gostishcheva O V.

Clinicocytological evaluation of the efficacy of combined treatment of chronic obstructive bronchitis (COB) in exacerbation with application of laser radiation of blood was performed. Combined treatment with the use of He-Ne intravenous and transcutaneous radiation of blood was given to 32 patients with COB. 27 COB patients treated without blood irradiation served as control. In addition to conventional methods of examination and control of the treatment effect, cytological and bacteriological tests of BAL precipitate smears were made. Combined COB treatment with the use of laser blood radiation has an antiinflammatory action, promotes normalization of mucociliary transport, activation of phagocytosis and immune defense, cleansing of bronchial tree,

reduction of obstruction effective management of exacerbations. Hospitalization decreased 3-4 days. Blood irradiation has the advantages as a noninvasive method.

AN IN VITRO STUDY OF THE EFFECTS OF LOW-LEVEL LASER RADIATION ON HUMAN BLOOD

Dan G. Siposan

In the last time the study of the effects of Low-Level Laser Radiation (LLLR) on the blood is considered to be a subject of great importance in elucidating the mechanisms of action between LLLR and biologic tissues. Different methods of blood phototherapy have been developed and used in clinical purposes with benefic effects. This study investigates some in Vitro effects of LLLR on some selected rheologic indices of human blood. After establishing whether or not damaging effects could appear due to laser irradiation of the blood, we tried to find a new method for rejuvenating the blood preserved in haemonetics-type bags. Blood samples were obtained from adult regular donors (volunteers). HeNe laser and laser diodes were used as radiation source, in a wide range of wavelengths, power densities, doses and other parameters of irradiation protocol. In the first series of experiments we established that LLLR does not alter the fresh blood from healthy donors, for doses between 0 and 10 J/cm3 and power densities between 30 and 180 mW/cm3. In the second series of experiments we established that LLLR does have, in some specific conditions, a revitalizing effect on the erythrocytes in preserved blood. We concluded that laser irradiation of the preserved blood, following a selected protocol of irradiation, could be used as a new method to improve the performances of preservation: prolonging the period of storage and blood rejuvenation before transfusion.

[The mechanisms of action of extracorporeal helium-neon laser irradiation in acute exogenous poisonings]

Anesteziol Reanimatol. 1997; (4): 33-35. Nemtsev I Z; Luzhnikov E A; Lapshin V P; Gol'dfarb I S; Badalian A V.

Extracorporeal exposure to HeNe laser of 12 mW power was used in 57 patients hospitalised at the intoxication reanimation department with acute poisonings with psychotropic drugs. The clinical result was a decrease of the incidence of pneumonia in the patients with x-ray signs of venous congestion from 52% among those administered to physiochemotherapy to 24% after this treatment modality. Laser hemotherapy brought about a temporary normalization of the erythrocyte membrane permeability, which was changed biophysically by means of a diffractometer. Red cell aggregation was approximating the norm, decreasing by 20%, and platelet aggregation decreased by 17%. Analysis of the results brought as to a conclusion that He-Ne laser exposure is an effective source of singlet stimulation of molecular O2 evenly dissolved in the blood, which causes resonance oscillations of water difields. This leads to membrane depolarization, which is probably responsible for purification of polarised membranes from toxic agents fixed by them.

CHANGES IN SOME FUNCTIONAL AND BIOCHEMICAL PARAMETERS OF THE CIRCULATING HUMAN BLOOD AFTER

PERCUTANEOUS APPLICATION OF VISIBLE POLARIZED LIGHT AT A THERAPEUTIC DOSE

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Three years ago, our clinics started application of a Swiss phototherapeutic device BIOPTRON that allows an exposure of a small body area to visible incoherent polarized (VIP) light, whose spectrum and power density are close to the Sun visible radiation (400-2000 nm, 95% of polarization, 12 J/cm2). To elucidate physiological mechanisms and to specify indications for this type of phototherapy,we analyzed some biochemcal parameters in 26 healthy volunteers during the course of 10 daily irradiations of a body area, 400 cm2.In the Placebo group (n=16) the irradiation was imitated and 5 exfusions of 140 ml blood for 10 days for study was performed, like in the main group. A rapid statistically significant decrease of the glucose level in 65% of VIP-exposed volunteers (on average, by 10%) has been observed in 0.5 hr after VIP-session but no significant changes in the Placebo group. Subsequently, strongly depending on the initial level, there was a decrease or an increase of this parameter in most VIP-irradiated subjects. The correlation and dispersion analysis has revealed regulatory and normalizing effect of the VIP-sessions on the glucose content. In the Placebo group, this regularity was not detected. Deep changes were in parameters of lipid metabolism: an immediate decrease of triglyceride content, (from 1.14 to 1.00 mmole/l) and its gradual, statistically significant decrease by the end of the course. The analysis indicated both a regulatory and normalizing effect of the VIP-course on the content of these atherogenic lipids The increase in b-lypoproteins' level was observed in 24 hr as well as by the end of course in both groups. Hence, this effect was due to the hemoexfusion rather than the effect of light.A statistically significant increase of the level of anti-atherogenic lipid a-cholesterol (from 1,76 to 1.98 mmol/l), was found out at all periods of the VIP-course, whereas in the Placebo group this parameter decreased. The data obtained have allowed us to apply the VIP-therapy in 10 patients with X-syndrome. For comparison 10 other patients as well as 12 volunteers were irradiated with therapeutic doses of He-Ne laser light. A small number of examined subjects allows only preliminary conclusions. Unlike volunteers no significant decrease was revealed in the sugar and triglyceride levels, whereas b-lipoproteins' content decreased soon after the 1st session and by the end of the course of both VIP-therapy and laser treatment (by 32%). As to a-cholesterol, it increased in patients with initially low values and decreased in subjects with high level both after a single exposure to light and by the end of course. There were no significant differences in the studied parameters between the VIP- and laser-treated volunteers.

CHANGES OF THE CONTENT OF SOME CYTOKINES AND GROWTH FACTORS IN CIRCULATING BLOOD OF VOLUNTEERS EXPOSED TO VISIBLE POLARIZED LIGHT AT A THERAPEUTIC DOSE K.A.Samoilova, D.I.Sokolov, K.D.Obolenskaya, N.A.Zhevago Institute of Cytology of the Russian Academy of Sciences, St. Petersburg, Russia

The promotion of wound healing and immunomodulation are the cardinal indications for laser therapy. Since these complex phenomena involve participation of immunomodulators and growth factors circulating in blood, it is necessary to study effects of phototherapy their level. Using an ELISA, we determined the plasma levels of Il-b, TNF-a, INF-g, Il-10, and transforming growth factor (TGF-b) in healthy volunteers (n=15-20) in 0, 0.5, and 24 hr after exposures of their back (400 cm2) to a therapeutic dose of visible incoherent polarized (VIP) light (Swiss BIOPTRON-2 device, 400-2000 nm, 95% polarization, 12 J/cm2). As a control (Placebo) group, unexposed people were similarly tested after 2 exfusions of blood for study (30-40 ml for 24 hr). There were no changes of the IL-1b level in 0.5 and 24 hr after the VIP-exposure of 17 volunteers, however, the TNF-a content in 0.5 hr changed in 85% of the subjects: a very slight increase was revealed in persons with a low initial cytokine level (50% of all tested) and

a more marked decrease, in volunteers with a high initial cytokine level. The inverse dependence of the light-induced effects on the initial TNF-a levels is confirmed by a negative correlation coefficient r (-0.67). In other 22 volunteers a statistically significant increase in the INF-g level was found in 0.5 and 24 hr: its mean amount changed by 44 pg/ml (from 21 to 65 pg/ml), in some people, by 102-308 pg/ml. Meanwhile, in the Placebo group (n=7) a decrease in the INF-g content was observed, which presumably resulted from the hemoexfusion. There also were changes of the Il-10 and TGF-b levels in 78-85% of volunteers, a high dependence of these changes being found on the initial level: r=-0.96 (Il-10) and r=-0.60 (TGF-b). Indeed, in subjects with the low values of Il-10 (40% of cases) its level increased in 0.5 hr (from 9 to 49 pg/m) and, to a lesser degree, in 24 hr, while in the group with the high Il-10 content it fell markedly (from 150 to 5 pg/ml); in the Placebo group a significant increase of Il-10 was observed (from 67 to 126 pg/ml in 24 h). As to TGF-b, its content within 0.5 hr decreased almost twice in 40% of cases (from 20.4 to 11 ng/ml) and rose in the 40% of volunteers 1.5 times (from 7.9 to 11.8 ng/ml). In the Placebo group there was an elevation of the TGF-b level in 60% of the people, while a decrease, only in 27% of the tested persons (by 25%). However, in 24 hr the 2-fold fall of the TGF-b content was revealed already in 71% of the control group persons, whereas among the irradiated volunteers, it was revealed only in 40%. Thus, a single VIP-exposure of healthy people immediately increases the plasma INF-g level and produces a regulatory effect on the TNF-b, Il-10, and TGF-b content.

(Effect of intravascular low level laser irradiation used in avulsion injury).
Luo-Q, Xiong-M-G, Gu-H.. Chung-kuo hsiu fu ch'ung chien wai k'o tsa chih {Zhongguo-Xiu-Fu- Chong-Jian-Wai-Ke-Za-Zhi}. 2000;14 (1); 7-9.

The aim of this study was to explore the effect of intravascular He-Ne laser irradiation on skin flap survival after orthotopic transplantation in avulsion injuries. 58 cases suffering from avulsion injuries were treated by debridement and orthotopic transplantation of the avulsed flap within 6 hours, 31 of them received intravascular He-Ne laser irradiation and routine treatment, 27 received routine treatment as control group. The survival area and quality of avulsed flaps in the experimental group were superior to that of the control group after 15 days of operation, and the hemorheological items were markedly changed at 5 days after operation. The better flap survival after orthotopic transplantation in avulsion injury can be improved by intravascular He-Ne laser irradiation, through changed superoxide dismutase activity and hemorheological items in an optimal irradiation intensity.